PHILIPPINE JOURNAL OF SCIENCE

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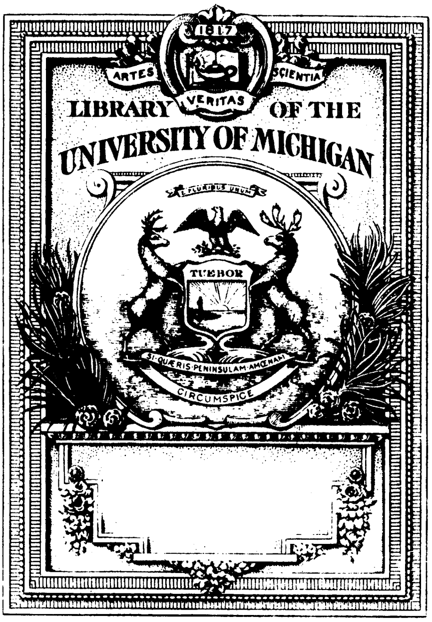
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THE PHILIPPINE JOURNAL OF SCIENCE

VOLUME 40

SEPTEMBER TO DECEMBER, 1929

WITH 100 PLATES AND 23 TEXT FIGURES

MANILA
BUREAU OF PRINTING
1929

VOL. 40, No. 1 SEPTEMBER, 1929

THE PHILIPPINE JOURNAL OF SCIENCE

MANILA
BUREAU OF PRINTING
1929

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THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science, Department of Agriculture and Natural Resources
Government of the Philippine Islands

Manuscript intended for publication should be sent to the editor. One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

The Journal is issued twelve times a year. The subscription price is 5 dollars, United States currency, per year. Single numbers, 50 cents each.

Subscriptions may be sent to the BUSINESS MANAGER, Philippine Journal of Science, Bureau of Science, Manila, P. I., or to any of the agents listed on the third page of this cover.

General
Walker

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No. 1, September, 1929

[Issued August 17, 1929.]

No. 2, October, 1929

[Issued September 10, 1929.]

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 40 SEPTEMBER, 1929 No. 1

MAYON VOLCANO AND ITS ERUPTIONS [1]

By LEOPOLDO A. FAUSTINO

Assistant Chief, Division of Geology and Mines
Bureau of Science, Manila

TWENTY-ONE PLATES AND THREE TEXT FIGURES

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INTRODUCTION

In the following pages it is proposed to describe Mayon Volcano and its immediate surroundings, to present more or less detailed descriptions of past eruptions and the eruption of 1928, and to give explanations of some of the phenomena observed. Strictly speaking Mayon is constantly in eruption, and the dates of eruption given here are to be taken to mean days of unusual or greater activity. The activity may be greater or less according to the frame of mind of the person or persons giving the reports. It is admitted that no two persons reporting on a volcano in eruption will find it in the same condition. However, there are cases where the accounts are a little exaggerated, as in the case of the last eruption. In order to satisfy the needs of a sensation-loving press some people sent in a few wild and highly-colored

[1] Submitted for publication November 15, 1928.

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reports. The present report contains an account of the 1928 eruption based on the personal notes of the writer. The first trip to Mayon for the purpose of observing the 1928 eruption was made early in the year. In answer to insistent telegraphic requests of the Governor of Albay, Father Saderra Masó, assistant director of the Weather Bureau, and the writer left Manila for the Mayon area January 20, 1928. The period from January 21 to 24 was spent in making observations around the volcano. On account of the northeast monsoon and the accompanying heavy and protracted daily rains the crater of the volcano was visible only occasionally. It was noted, however, that the activity consisted of feeble emissions of vapors, mainly steam, from the crater. The vapors took the regular form of solfataric emanations, without any shape or form, apparently without any pressure from behind, and disappeared as soon as they reached a short distance above the summit. The people were told there was no immediate danger of a violent eruption, at least until May or June.

In response to a series of telegrams from the provincial authorities of Albay Province the writer left Manila June 26 to make observations on the reported activity of Mayon Volcano. Arriving in the Bicol region he found Mayon in mild eruption, throwing out dust and ashes. People were leaving their homes, and the general population was panicky. June 27, 28, and 29 were spent on the slopes of Mayon itself with Col. José de los Reyes, of the Philippine Constabulary. On July 1 the following report was handed the Provincial Governor.

THE GOVERNMENT OF THE PHIIIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE
MANILA

LEGASPI, ALBAY, *July 1, 1928.*

Hon. MARIANO LOCSIN,
Provincial Governor,
Legaspi, Albay.

MY DEAR GOVERNOR: In compliance with your verbal request, I take pleasure in presenting herewith my observations on the present activity of Mayon Volcano.

1. Up to the present time the eruption has been a very mild one and has consisted merely in a quiet extrusion of lava from several places near the summit of the cone. The molten material issues from several notches on the sides of the crater and rolls down the slopes towards Libog in the form of rock streams and avalanches, red hot and incandescent, presenting fireworks display at night.

2. Unless conditions suddenly change, I see no cause for alarm and I see no reason why the people should not return to their homes.

3. Present indications are that the Mayon Volcano will continue in this more or less active state. The emission of smoke (dust-laden steam) and small lava flows may continue for some time and perhaps a little shower of volcanic dust may fall in the neighboring towns.

4. There is danger at the present time from the fragmental materials lying unstable on the slopes of the volcano, which with the coming rains may sweep down the mountain sides in torrential flood. The barrios of Arimbay and Bigaa of Legaspi and most of the barrios of Libog on the slopes should be warned.

Very truly yours,

LEOPOLDO A. FAUSTINO,
Assistant Chief, Division of Geology and Mines.

While the writer was preparing to return to Manila he sent the following telegram to the Director of the Weather Bureau:

LEGASPI, ALBAY, *July 2, 1928.*

FATHER SELGA, *Weather Bureau, Manila.*

No increased activity. Mayon continues mild eruption. Constant emission of grayish white smoke (dust-laden steam). Occassional small lava flows from the crater. Present conditions indicate prolonged activity without danger. Returning to-day Bicol Express.

FAUSTINO.

Subsequent developments sustained both reports. The climax of the present activity was probably reached July 19 and 20, and the week following. July 22 the writer was again in the Mayon area, this time in company with Father Selga, director of the Weather Bureau, and Vicente del Rosario, chief of the Executive Bureau, who representing Governor-General Stimson, was chief of the relief work. July 24 Father Selga and the writer, while making observations on the slopes of the volcano in company with W. L. Bowler, of Legaspi, had the experience of being enveloped by a dark heavy ash-cloud without suffering any ill effects.

During the latter part of August Father Selga revisited the Mayon area to collect more specimens of the volcanic products and to obtain temperature measurements. At that time it was noted that the volcano was returning to its normal state of mere emission of steam vapors.

Grateful acknowledgment is here made of the many courtesies extended by the provincial authorities and inhabitants of Albay during the course of the investigation, and in the preparation of this report the writer wishes to record his apprecia-

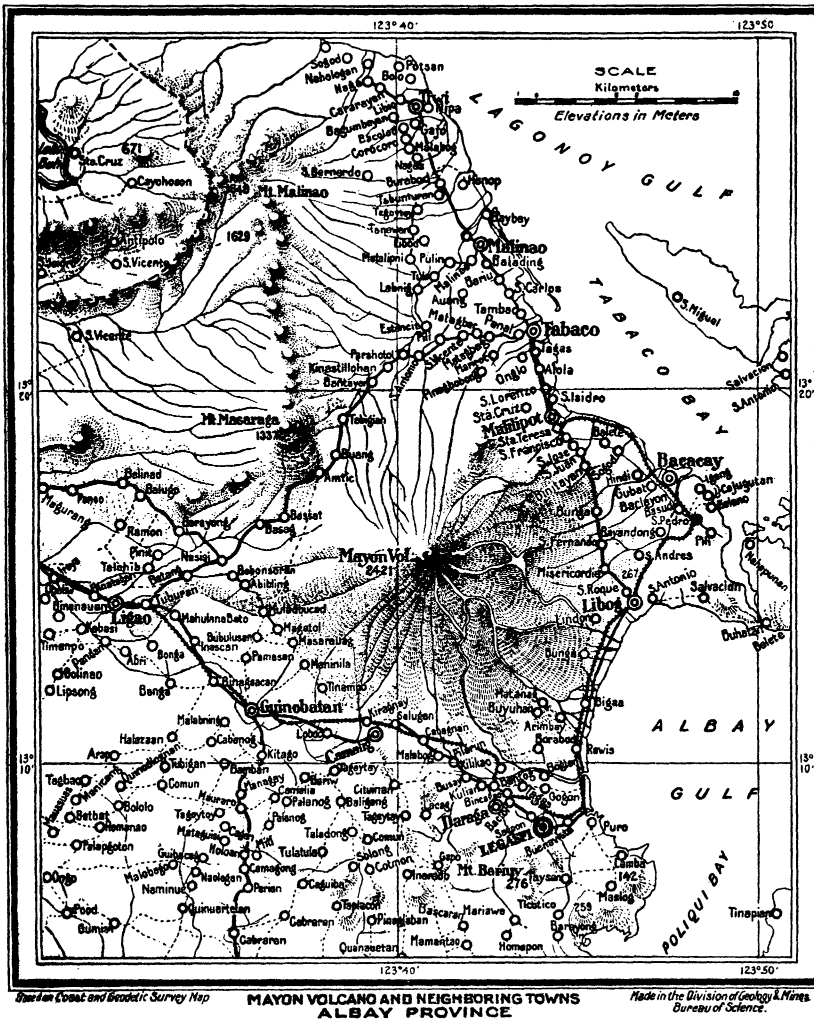

FIG. 1. Mayon Volcano and the neighboring towns in Albay Province.

tion of the help and encouragement given by Father Selga and Father Saderra Masó of the Weather Bureau and Director Brown and the scientific personnel of the Bureau of Science.

GEOGRAPHY

Mayon Volcano is situated in the extreme southeastern part of Luzon, in Albay Province in latitude 13° 16′ north and longitude 123° 41′ east. From Manila it may be reached via the Manila

Railroad in less than twenty-four hours. Rising from a broad base on the western shores of Albay Gulf between the towns of Legaspi and Tabaco it forms a remarkably symmetrical mountain and has rightfully earned the name of the "most perfect cone in the world." The summit terminates in a small crater 2,421 meters above sea level according to determinations by the United States Coast and Geodetic Survey.[2] This volcano has been described by Abella (1) as *una inmensa tienda de campaña cónica* (an immense conical tent). The more or less circular base may be said to have a radius of about 10 kilometers. On the periphery of this base are located the most important towns of Albay Province; namely, Tabaco and Malilipot on the northeast, Libog on the east, Legaspi and Daraga on the southeast, Camalig on the south, and Guinobatan and Ligao on the southwest. In addition there are several barrios and settlements on the slopes of the volcano, and some people from Masarawag, a barrio of Guinobatan have built camps almost halfway to the summit.

According to the 1918 census the number of people living in the immediate vicinity of Mayon Volcano is 178,794. This estimate

[2] This is the figure given on all United States Coast and Geodetic charts since 1910. In answer to our request regarding the present height of the Mayon on account of the last eruption, the Director of Coast Surveys was good enough to furnish the following information:

"The published height of 2,421 meters was determined for geographic and navigation purposes only. While it is, perhaps, safe to say that this height is correct to within 10 or 15 meters, it is undoubtedly not of sufficient accuracy to compare with a more accurate determination, if made at the present time for the purpose of noting any change of height due to the recent disturbances.

"It is difficult to secure accurate observations for elevation in the Islands because of the excessive refraction. This refraction can be determined only by means of reciprocal observations. To secure these would necessitate ascending Mount Mayon with a theodolite and awaiting for favorable observing conditions. Unfortunately the hydrographic work of the *Fathomer* will not permit of the delay which would be necessary to secure this information."—L. O. Colbert, lieut-commander, C. and G. S. Director of Coast Surveys.

It is certain that the height of Mayon Volcano has changed from time to time, perhaps more after each eruption. The differences in the following determinations, however, are due more to the methods used rather than to the elevation itself. In 1859 Jagor's own barometric reading was 2,374 meters. According to Abella and Coronas the Spanish Hydrographic Commission gives 2,522 meters, the determination having been made sometime before 1870. In 1881 Abella gives the height of Mayon as 2,734 meters, while d'Almonte's map of 1883 gives 2,527 meters.

includes all the inhabitants of the region within a radius of 15 kilometers, and is distributed as follows:

TABLE 1.—*Population of towns in the vicinity of Mayon Volcano.*

Town.	Population.
Bacacay	20,211
Camalig	19,772
Daraga	([a])
Guinobatan	25,113
Legaspi	52,756
Ligao	21,467
Libog	7,391
Malilipot	7,272
Tabaco	24,812
Total	178,794

[a] Included in Legaspi. The name of the municipality of Albay has been changed to Legaspi by Act No. 3253 of the Philippine Legislature, approved December 3, 1925.

"Act No. 3253.—An Act changing the name of the municipality of Albay, in the Province of Albay, to Legaspi, and for other purposes.

"Be it enacted by the Senate and House of Representatives of the Philippines in Legislature assembled and by the authority of the same:

"Section 1. The name of the municipality of Albay, capital of the province of the same name, is hereby changed to Legaspi: *Provided, however,* That all provincial and municipal government offices and their dependencies shall continue in the former municipality of Albay.

"Section 2. This Act shall take effect on its approval.

"Approved, December 3, 1925."

These towns are connected with each other by first-class roads, and the Ammen Transportation Company maintains a fleet of autobuses which run on regular schedule. The first-class road of the province runs around the volcano and at a point called Sabloyon, midway between Tabaco and Ligao, the provincial authorities have constructed an observation platform, from which an imposing view of the volcano can be had at close range (about 6 kilometers) across a deep ravine. The Manila Railroad winds around the southern and eastern slopes and terminates in Tabaco. During the last eruption, upon being assured that there was no immediate danger, the enterprising manager of the Legaspi Division of the Manila Railroad, Domingo Onrubia, ran excursion trains at night to view the fireworks of the volcano.

From the surrounding towns the land rises gradually, at times going down in a broad depression, at other times rising abruptly to form small hills. These small hills are cinder cones of low elevation. A number of these hills merit attention. To the northeast and, in a way shielding the town of Malilipot from the fury of Mayon, is a line of two or three prominences running

northwest and southeast or almost parallel to the long axis of Tabaco Bay. The most northern of these prominences is the highest and has an elevation of 457 meters. This range of hills is called Tancolao and extends southwest of barrio San Antonio of the municipal district of Tabaco, where it ends in an abrupt cliff. At the foot of the cliff is the provincial road from Tabaco to Ligao. To the north of Legaspi is a more conical hill called Lin̄gion, which rises to an elevation of 169 meters.

Aside from these minor undulations near the base, which do not materially affect the sine curve of the slope, Mayon rises like a symmetrical cone and the slopes present the same pleasing curve from whatever direction it is viewed. At first the rise of the land is scarcely perceptible, then there is a gradual increase in the angle of the slope, and as the summit is approached the fragmental product of previous eruptions assumes the angle of repose varying from 35 to 45°. Mayon Volcano is not only the most beautiful of all the volcanoes in this region but is the highest, and can be seen from steamers approaching San Bernardino Strait and also from Burias and Ticao Islands and farther.

The flanks have ravines radiating from the summit, those on the eastern slopes are more marked than those on the other sides. Toward the base of the mountain some of these ravines have a depth of 50 meters and a width of as much as 30 meters. Near the summit they are not so deep and appear more like grooves when seen from the neighboring towns. However, when viewed farther away the scars disappear and the perfect symmetry of the cone becomes impressive. Even the outline of the summit, which is being gradually roughened by weathering and erosion, seems to taper almost to a point.

There is no beaten trail to the summit. Sometimes the route leads through one of these ravines, at other times on a hogback between two ravines. On account of the slope and the loose material consisting of cinders, scoriæ, and lapilli lying upon a somewhat harder base of volcanic material the last 500 or 300 meters of climb is beset with difficulties. A rope and a good climbing stick are indespensable. Tennis shoes and native *alpargatas* are more reliable than heavy boots or hob-nailed shoes.

The summit of Mayon was reached many times even during the Spanish occupation. Huerta(8) writes that in 1592 a Franciscan friar, Reverend Pedro Ferrer, attempted to climb the mountain to dispel the superstitions of the natives regarding the

volcano. He did not reached the top, but he brought down a sample of sulphur, which was probably the first sulphur discovered in the Philippine Islands. In the same year another Franciscan friar, Reverend Estevan Solis, accompanied by a lone guide made a similar attempt but was prevented from reaching the summit by three *bocas* (mouths or depressions). According to Jagor(9) two young Scotchmen, Paton and Stewart by name, were the first ones to reach the top, although in "Trabajos y Hechos Notables de la Soc. Econom. de los Amigos del Pais," for September 4, 1823, it is said that "Don Antonio Sigüenza paid a visit to the volcano of Albay on the 11th of March, and that the Society ordered a medal to be struck in commemoration of the event, and in honor of the aforesaid Sigüenza and his companions." In 1859 Jagor himself made the ascent.

In 1876 von Drasche(7) reached the summit, and his description of the summit with a sketch was published two years later. It is generally known that a number of Spaniards and Filipinos have made the ascent from time to time although no records have been made of the trips as the ascent was considered as a not particularly dangerous feat. Since the American regime a number of expeditions have been recorded. In 1902 a party of Americans ascended the crater and took many photograps. In 1911 Bishop McDonald of Legaspi and party reached the summit and his photographs of the crater are shown in this report. In 1922 a party from Legaspi consisting of some thirty persons made the ascent. Carlos Stillanopulos, one of the members of the party, described the trip as follows:

> We started early in the afternoon and managed to reach close to the end of vegetation before nightfall. There we camped and had our dinner. We were well stocked with provisions, and it was a merry crowd, singing and making all kinds of noises. Leaving our base camp early the next morning we reached the rim of the crater a little before noon and after taking a number of pictures of the party started back for the base camp. Some of the members reached Legaspi that night but most of the party remained at camp and returned to town the next morning. It was not particularly a dangerous climb but required careful foot work and a good eye for small boulders which might be turned loose in one's direction. Near the crater we found the skeleton of a human being, which some of the members of the party thought might be the guide of some Americans who ascended the Mayon in 1920 and who was lost in the typhoon but who was thought to have returned later.

The United States Army fliers were able to take some good photographs of the summit during the early days of the 1928

activity. Arriving late in the afternoon of June 29 two Army fliers from Camp Nichols, near Manila, circled the volcano at an altitude of about 2,500 meters. According to Lieut. George W. Goddard on account of the heavy mantle of cumulus clouds he steered nearer the summit than he intended and came within 200 meters of the crater before he knew his position. He says that he felt the heat very strongly and inhaled a quanity of sulphur gases. Lieutenant Goddard estimated the diameter of the crater to be about half a kilometer.

He described it as apparently almost circular, with perpendicular walls, and a deposit of cindery material on the sides, and a pool of bubbling hot lava in the center. On account of the escaping gases and steam vapors it was difficult to make detailed observations of action in the crater.

The following notes regarding the crater are based on observations and photographs of those who had made a trip to the crater of Mayon during the interval between the 1900 and 1928 eruptions. All descriptions agree that the crater rim is notched at several places, but the main chute is on the eastern side in the direction of Libog. This main chute seems to divide the crater into a north and a south rim. Those who have stood on the rim or on some of the projecting rock promontories estimate the diameter of the crater between 300 meters and 500 meters with a more or less ragged edge made by immense bowlders standing on one side as if ready to fall at a moment's notice. It appears that the highest part of the rim is toward the west and southwest or in the direction of Ligao. Several persons had descended into the bottom of the crater and had taken good pictures of the pit. Several of which appear in this report. The bottom of the pit is estimated to be bewteen 50 and 100 meters below the crater rim. It consists in part of an apparently thick layer of heavy subangular bowlders between which are emitted steam vapors and other gases, in part of smaller particles, granulated fragments, and sand, and in part of small pools of alkaline waters, highly heated and vaporizing. These volcanic emanations sometimes assume such proportions as to appear like a characteristic "panache" of volcanic mountains. At the bottom of the crater some of the rock materials are covered with incrustations which may be true volcanic sublimates. Volcanic sublimates are generally deposited by or from volcanic gases. Among the numerous incrustations generally encountered among volcanic vents, only two have so far been identified in the crater of

Mayon. A small sample brought by Mr. Wiley, of the Manila Railroad Company, and which he says was taken from between two rock masses on the walls of the crater proved to be aluminium sulphate. According to A. D. Alvir, geologist of the division of mines, Bureau of Science, the white earthy mineral has all the properties of alunogen, which may be formed by acid solutions acting upon aluminous rocks. The sample tastes like alum. The most conspicuous of the volcanic sublimation products in the Mayon crater is native sulphur, where it occurs around numerous vents both on the floor and on the sides.

The walls inside the crater are perpendicular and consist of large blocks, lapilli, some scoria, and volcanic sand in intimate mixture with occasional wavy lines indicating structure. It appears that the irregular stratification is the result of successive deposits and flows during past eruptions. At the base of the perpendicular walls are talus deposits varying in size according to recency of formation, the more recently formed reaching higher on the walls. No dikes are apparent on the walls, although lines of loose rocks simulating dike structure run irregularly from the rim to the base of the crater.

The view from the summit of Mayon stirs the imagination, and many a climber has remarked it is well worth the hardship of the climb. Land and sea, fields and forests, villages and towns with their churches and government buildings stretch out in diminutive form as far as the eye can see. Parties generally plan to reach the crater during early morning or, at the very latest, at noon, as then the summit is uncovered and no clouds obstruct the view. Even then the solfataric vents give off enough steam vapors to make the surrounding air hazy.

CLIMATE AND VEGETATION

In order to understand better the effects of Mayon eruptions it is necessary to give a few salient features of the climate of the Bicol region, particularly with regard to rainfall and wind direction. On account of its latitude and position with reference to the Pacific, the Mayon area has rainfall throughout the year, with a minimum in April and May and a maximum in November and December. Given a rich volcanic soil with rainfall throughout the year it is not to be wondered that the plains of Albay are ever green with vegetation. Sometimes, however, the condensation of moisture reaches serious proportions and

water falling on the slopes of the volcano flows in torrents first in the ravines and then across the lowlands carrying everything in its path in its rush to the sea. Floods of this nature are particularly dangerous in view of the fact that as a result of previous eruptions fragmental materials, incoherent and merely lying in unstable equilibrium on the slope, are ready without a moment's notice to come down, made mobile by the onrushing waters.

There are on record at least two great disasters caused by typhoons in which the rainfall on the slopes assumed great proportions and caused volcanic materials to roll down to the plains and on to the sea after the manner of mud flows, only with more mobility and with greater rapidity. Huge bowlders of volcanic rock, 5 or 6 meters in diameter, resting on volcanic sand can be moved with sheets of water 5 to 10 centimeters deep by carrying away the sand particles underneath and disturbing the equilibrium. Once the blocks on the slopes start moving there is no stopping until the low depressions are reached or the materials are deposited in Albay Gulf. The first great disaster of this kind on record was in October, 1766, when it is estimated that thousands of people perished and much property was destroyed. About one hundred years later, in November, 1875, another flood caused heavy destruction and the number of victims is estimated at 1,500 saying nothing, of course, of the money value of the property damaged. In both of these disasters the path of the waters was one of desolation, a mere expanse of bowlders and sand with pieces of wood and branches of twigs to mark the place where once was a field, a garden, or a thriving community.

In 1915 a stream flood again occurred and brought down bowlders of varying sizes, sand and gravel, and other materials, which covered the tracks of the Manila Railroad between Legaspi and Libog and also the provincial road. For more than two weeks communication between the two towns was suspended. Similar floods have occurred from time to time, and they have caused considerable damage to crops and to other agricultural products. Many more destructive floods have occurred than are recorded, and some of the people have devised ways and means to minimize destruction. Some plantation owners of Camalig struck the novel idea of building dams, which protected their property to some extent but diverted the water to some other property so the destruction was no less.

Table 2 shows the monthly average of rainfall in Legaspi at the foot of the volcano for sixteen years.

TABLE 2.—*Monthly average of rainfall at Legaspi, Albay.*

[Census of the Philippine Islands for 1918 1 (1920) 345.]

Month.	mm.
January	376.3
February	273.2
March	171.5
April	126.4
May	133.6
June	207.3
July	230.7
August	172.5
September	251.7
October	328.8
November	348.8
December	488.5

In the consideration of the effects of eruption the direction of the wind is also important, as the wind is the medium by which the volcanic sand, ash, and dust thrown into the air are carried to near-by and distant places. The fate of the barrio or community is determined in part by the direction of the wind and its permanence in that azimuth. In the following table of wind directions it can readily be seen that the prevailing wind during the first six months is northeast and east northeast while that during the last six months is southwest and west southwest. These wind directions are those observed near the surface.

TABLE 3.—*Monthly percentages of wind directions at Legaspi, 1903–1908.*

[From the Philippine Weather Bureau.]

Direction.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
N, NNE	30	25	22	18	11	6	3	1	4	13	27	32
NE, ENE	51	50	52	50	36	25	9	5	8	27	41	49
E, ESE	7	10	16	17	15	11	4	5	5	7	8	6
SE, SSE	-----	-----	-----	1	1	1	1	1	1	1	1	0
S, SSW	-----	-----	-----	1	3	6	7	6	7	4	1	0
SW, WSW	-----	-----	-----	1	5	13	35	46	35	12	3	1
W, WNW	-----	-----	-----	-----	2	4	10	14	10	5	2	1
NW, NNW	1	-----	-----	-----	1	1	1	1	2	1	1	1
Calm	11	14	9	12	28	33	31	23	28	29	16	10

At higher levels of the atmosphere, however, the air sometimes takes a different direction of movement, and very fine

materials thrown into the air and reaching the height of 10 kilometers or over may not be blown in the direction of the wind recorded at the surface of the land. Oftentimes the direction of air movements at higher levels is unknown, but sometimes it can be observed. Table 4, taken from a Weather Bureau report, will show that there is a difference in the direction of air movement at higher and lower levels of the atmosphere.

TABLE 4.—*Form and direction of cloud observed at Legaspi station, Albay, July, 1920.*

[Explanation of symbols: Ci, cirrus; Ci-S cirro-stratus. A-Cu, alto-cumulus; Cu, cumulus; N, nimbus; Fr-N, fracto-nimbus; Cu-N, cumulo-nimbus.]

Day.	6 a. m.			2 p. m.		
	Amount 0-10.	Upper.	Lower.	Amount 0-10.	Upper.	Lower.
1	9	Ci-S	Cu-N WSW	7	Ci-S	Cu-N WSW.
2	4	Ci	Cu	2	Ci	Cu SSW.
3	7	Ci	Cu	5	Ci-S	Cu SSW.
4	9	Ci-S	N ENE	8	Ci-S	Cu-N ENE.
5	8	Ci-S	Cu NE	8	Ci-S	Cu-N ENE.
6	8	Ci-S	Cu SW	7	Ci-S	Cu SW.
7	8	Ci-S	N WSW	9	Ci-S	Cu WSW.
8	5	Ci-S	Cu SW	10	Ci-S	Cu-N WSW.
9	10	Ci-S	N	10	Ci-S	N WSW.
10	10	Ci-S	Fr-N WSW	10	Ci-S	N W.
11	10	Ci-S	N W	10	Ci-S	N W.
12	10	Ci-S	Fr-N WSW	10	Ci-S	Fr-N WSW.
13	10	Ci-S	Fr-N WSW	10	Ci-S	Fr-N WSW.
14	10	Ci-S	Fr-Cu WSW	7	Ci	Cu WSW.
15	5	A-Cu WSW	Cu WSW	5	Ci	Cu WSW.
16	10	Ci-S	Cu WSW	9	Ci-S	Fr-Cu WSW.
17	9	Ci-S	Cu-N WSW	6	Ci-S	Cu WSW.
18	7	A-Cu WSW	Cu WSW	10	Ci-S	Cu-N WSW.
19	10	Ci-S	N WSW	10	Ci-S	Fr-N WSW.
20	10	Ci-S	Fr-N WSW	10	Ci-S	Fr-N WSW.
21	10	Ci-S	N WSW	10	Ci-S	Fr-N WSW.
22	10	Ci-S	Fr-N WSW	8	Ci-S	Cu WSW.
23	6	A-Cu ESE	Cu WSW	8	Ci NNE	Cu WSW.
24	2	C	Cu WSW	3	Ci	Cu WSW.
25	5	Ci	Cu WSW	7	Ci	Fr-Cu WSW.
26	10	Ci-S	Fr-Cu WSW	10	Ci-S	N WSW.
27	10	Ci-S	N WSW	10	Ci-S	N WSW.
28	10	Ci-S	N WSW	10	Ci-S	N WSW.
29	8	Ci-S	Cu WSW	7	A-Cu	Cu WSW.
30	6	Ci	Cu WSW	3	Ci	Cu WSW.
31	6	Ci-S	N WSW	7	Ci E	Cu-N WSW.
Mean	8.1			7.9		

Mayon's eruptions have had no small effect on the vegetation on its slopes. As a matter of fact the present vegetation shows in no small degree the sphere of previous eruptions. The northern and western slopes are covered with vegetation almost to the summit, while the southern and particularly the eastern slopes are practically barren except for a few isolated spots of grasses and small trees. On the northern and western slopes there are forest trees with trunks ranging from 10 to 50 centimeters in diameter, heavily covered with air plants and without the usual entanglement of climbing vines. Apparently no heavy flows of lava and incandescent materials have taken this direction for a very long period, although it is evident from the nature of the ground that during the previous eruptions some of the materials thrown into the air have fallen and have run down the northern and western slopes. During the 1928 eruption small streams of rock materials thrown in the direction of Guinobatan reached the 1,000-meter elevation, and descended following the ravines. Toward Masarawag the forest belt stops at an elevation of 1,000 meters, abacá plantations and isolated patches of coco and other trees cover the rest of the slope down to the base. On the broad base of Mayon Volcano the dominant crop is abacá with a sprinkling of coco palms. These plantations, however, give way to a scanty vegetation on the southern and eastern slopes particularly those places in the direction of the streams of sand and big bowlders. At an elevation of 300 meters cogon and other grasses predominate. As a matter of fact the lower slopes of Mayon Volcano may be described as covered with triangular areas of cogon and other grasses with the apex of the triangles reaching the higher portions and between which are areas of barren volcanic ejecta. A small irregular belt of stunted trees occurs on the eastern slopes at a 600-meter elevation directly in front of the main lava flow of the 1928 eruption. Upward beyond the cogon belt is a scanty vegetation of small grasses and shrubs with patches of raspberries. The last 500 meters to the summit is practically barren, nothing but sand and bowlders lying at the angle of rest, and sliding downward at every opportunity.

GEOLOGY

Mayon Volcano is a cinder cone, whose form is determined by the angle of repose of fragmental materials, mostly ash, lapilli, and volcanic ejecta, which have been thrown into the air during

eruptions and have fallen at or near the crater or exuded through the notches on the sides of the crater. These materials pile up around a restricted orifice. Anything in excess of the angle of repose rolls down the slopes to rest at a lower elevation or at a lower angle of slope. As a result the slope is very steep near the summit but descends gradually into the lowlands at the base. In other words there is a very gradual rise from the plains to an elevation of about 500 meters or within a 6-kilometer radius from the crater. The vertical outline of the volcano assumes the hyperbolic sine curve, which Becker[3] was able to represent by a mathematical formula.

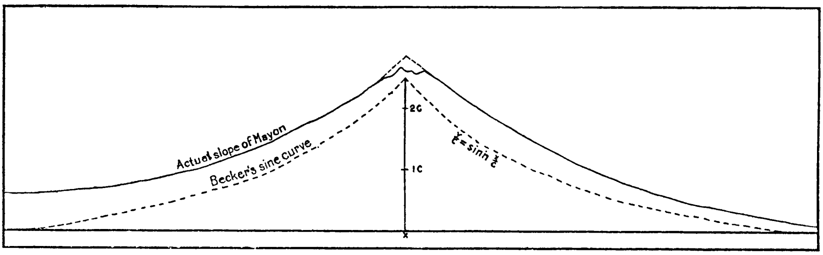

FIG. 2. Form of cinder cones.

It appears from Becker's discussion of the formula that the form assumed is dependent upon the resistance of the material to crushing. During each eruption materials ejected into the air and falling at or near the summit as well as those flowing from the crater are distributed evenly on the slope so that the vertical depth of the added material is practically the same from the summit to the base. Becker (5) explains that "of course, more material falls near the top than near the bottom, but more rolls down from the steeper slopes of higher portions than from the gentler slopes near the foot."

It is generally agreed that the framework of Mayon Volcano consists of layers of lava flows and fragmental materials ejected from a restricted orifice. Surface manifestations point to only one volcanic conduit, although Abella (1) spoke of numerous fissures and subordinate openings, which, according to him, were not preserved on account of the steepness of the slope and the incoherent character of the materials. During the 1928 eruption Father Selga and the writer watched particularly for signs of

[3] 18th Ann. Rept. U. S. Geol. Survey, pt. III (1898) 20–25.

subordinate openings but none appeared. If there have been subordinate openings or parasitic cones on the slopes they have not left any evidence of their existence and present indications are that has been only one opening.

Along the ravines and gullies on the upper slopes some stratification of materials was observed. The external structure on these higher slopes consists of layers of fragmental materials and consolidated ash. The ash has hardened to a relatively firm continuous mass varying in thickness from 10 to 50 centimeters. These beds can be readily recognized in some of the photographs.

The materials found on the slopes are the same as those found on any other volcano, large angular masses of solidified lava, sometimes partly fused, agglomerates, scoriæ and cinders of varying sizes and shapes, and volcanic sand. The lava from this volcano has been the subject of investigation by a number of workers. It was described by Roth and von Drasche(7) as dolerite, by Oebbeke as olivinitic augite-andesite, and by Abella(1) as essentially basalt with feldspar and augite as the predominating minerals. The Mayon area was mapped by Adams and Pratt(2) as basalts with andesites. A. D. Alvir, geologist in the division of mines, Bureau of Science, examined a number of thin sections of rocks from previous eruptions and from the 1928 eruption. His notes follow:

> Apparently Mayon has been erupting the same types of lavas as shown by the remarkable uniformity in the mineral composition of the samples taken for examination. The lavas of previous eruptions are andesitic basalt with calcic plagioclase (labradorite) predominating. The texture is andesitic, automorphic porphyritic with a glassy hemotitic mesostasis containing microcrystals of feldspar and hypersthene. The automorphic phenocrysts are labradorite (a few andesine) and augite. Most of the augite and a few of the feldspar phenocrysts have their edges resorbed. The majority of the feldspar, however, have peripheral and zonal growths which are clear of inclusions while the minerals within the former boundaries have inclusions. The other accessory minerals are magnetite and hematite. A sample of lava from the present eruption collected by the Constabulary detachment shows the same automorphic porphyritic texture and the same abundance of augite and labradorite feldspars. The groundmass is glassy, slightly cryptocrystalline, and dark.

It cannot be definitely stated just when Mayon Volcano first appeared, but it is reasonably certain that it is one of the youngest, if not the youngest, of the line of volcanoes in the Bicol region. It would seem that the original vent was made during the closing period of the Tertiary or early Quaternary by rifting

through tertiary sediments. The volcanics and eruptives of this region are known to be younger than the Tertiary formation. The rise has been gradual but more rapid than the ravages of erosion and new extruded materials filled up the ravines and gullies formed, so that the repeated activity was able to keep the external form from disfigurement. Each eruption has added more materials to the cone and has gone toward perfect symmetry and form, and the ejected materials have served to smooth over the irregularities caused by erosion and weathering.

PREVIOUS ERUPTIONS OF MAYON [4]

Mayon Volcano is the most active cone in the Philippines. It has had periodic eruptions during the last three hundred years and it may be considered to be in normal state when volcanic vapors, sometimes dust-laden, appear at the summit. The earliest record of Mayon in eruption was made about 1616 by Spilbergen, although no details were given regarding the intensity or destruction. During the following hundred or more years accounts of voyagers from Mexico approaching San Bernardino sometimes record the existence of a volcanic mountain in the distance emitting "smoke."

The first eruption to be described at length was July 20, 1766, and lasted six days. It is said that a column of "fire" rose from the crater and a current of lava descended the eastern slope. According to the records of the Franciscan fathers Mayon continued its mild activity until 1800, when greater activity was shown. Large amounts of stones, sand, and ashes were thrown out causing much damage to the towns of Cagsaua, Budiao, and others, including some cultivated fields. During the last of October of that year the action was more violent and more destruction was caused to the towns.

February 1, 1814, the most violent and destructive eruption of Mayon occurred. It was preceded by local earthquakes the day before, continuous during the night, and culminating in a violent eruption at 8 o'clock in the morning. Following a strong quake, a huge column of dust-laden steam vapors rose from the crater, and darkened the whole surroundings. To add to the terrifying scene volcanic lightning flashed back and forth. A torrent of "fire, lava and large hot stones" rolled down the southern slope, destroying everything in its path. The towns

[4] Based on reports of Aragon, Abella, Coronas, Masó, and others.

of Camalig, Cagsaua, and Budiao and half of Albay and Guinobatan were laid in ruins, and according to records 1,200 people were killed.

During the years following, Mayon emitted volcanic vapors in greater or less quantities. In June, 1827, there began a period of activity which lasted until the beginning of the following year. In 1834 small flows of incandescent lava from the crater were noted. This activity was maintained until May, 1835, and there were times when bombs and ashes were thrown into the air but fell not far from the crater. Noises similar to loud thunder were heard. On January 21, 1845, subterranean noises were again heard followed by a small eruption of ashes at the crater lasting ten minutes. This was followed by another eruption and still another at intervals of fifteen and thirty minutes, respectively. An ash cloud appeared at the top of the volcano and was blown by a northeast wind, and ashes fell on Camalig and Guinobatan. During the week following there could be heard in the daytime sounds that were described as great multitudes of rocks striking against each other and at night as of a distant waterfall. A similar eruption occurred the following year, 1846, and in 1851 there were two other small eruptions of ashes.

On July 13, 1853, an eruption occurred which lasted only a few hours but which caused considerable damage to life and property. This eruption was preceded by loud subterranean noises, without local earthquakes, followed by an extrusion of an immense column of dust, treelike and spreading at the top. Incandescent rocks rolled from the summit on the slopes to the base of the volcano destroying many houses and causing the death of thirty-three persons. Although the eruption lasted only one afternoon all the towns at the base of the volcano were covered with ashes.

March, 1855, there was another small eruption. During the year 1858 there was considerable activity consisting of quiet flows of lava and incandescent materials on the sides of the volcano with emissions of small quantities of ashes at the crater. From 1861 to 1868 there were frequent outbursts of ashes and dust, but none assumed dangerous proportions. At times during this period there could be seen a glow at the summit. December 17, 1868, dust-laden clouds, low and spreading, appeared at the summit, and some ashes fell.

December 8, 1871, there occurred an eruption that caused the death of three persons. Early in the morning loud subterranean noises were heard, and between 7 and 8 a. m. three particularly strong ones, after which an immense column of dust-laden cloud rose majestically and then spread to shower ashes and dust on all the neighboring towns. The northeast wind carried the ashes toward Camalig and Guinobatan, and at both places it was so dark that the people had to use lamps. There were mud balls the size of bullets or smaller. From the crater molten lava and incandescent rocks rolled down the sides. At 10 a. m. it cleared somewhat, and it was found that a deposit of ashes 4 millimeters in thickness had covered the fields, roofs of houses, and other places. At 1 p. m. there was a similar explosive eruption with lightning and thunder. In the evening the whole mountain could be seen illuminated with the lines of red-hot rock streams running in the direction of Legaspi. The waters in the streams became turbid on account of the suspended ash materials. In the "visita" of Bocton, or Bogton, two persons were suffocated and in Buyuan, or Buyuhan, one was burned.

In September, 1872, there was an eruption which lasted four days. There was emission of ashes and lava, and subterranean rumblings. The following year, 1873, a similar eruption occurred, this time with more vigor and activity, and lasted from the middle of June to July 22, with the climax June 20.

July 6, 1881, began a period of prolonged activity which lasted until the middle of the following year. In spite of the heavy rains the evening of July 6, 1881, the people of Tabaco noticed a glow at the summit of the volcano which was due to a reflection of molten lava and incandescent materials. July 16 incandescent rocks were seen rolling down the slopes following the ravines and barrancos. The activity was repeated at 11 p. m. of July 22 with distant rumbling sounds. Mayon continued more or less active during the months following. At 11.30 a. m. November 21 heavy dark clouds appeared at the summit and ashes began to fall, while greater quantities of incoherent and fragmental rock materials more or less incandescent descended the slopes. Their lines of descent were marked by white vapors and gases emanating from the materials. Shortly after 12 noon there was heard a deafening noise, and at 2 p. m. the whole mountain was covered with dark ash-clouds. In the towns to the south and southwest the air was heavy and sultry. With the

east wind blowing most of the ashes in the air fell on Camalig and Guinobatan. The phenomenon was repeated with similar manifestations, December 14. There followed a gradual decrease in the activity. From November 21 to the first days in December, particularly November 23 and 24 and December 2, there were tranquil emissions of molten lava and fragmental materials from the crater along the barrancos toward the south, and a little to the east and west of south, which reached 400 to 600 meters below the summit. The dust-cloud accompanying the eruption November 24 assumed the imposing height of 600 meters. None of the reports mentioned showers of ashes, and subterranean noises and rumblings were noted only a few times.

Again in 1886 and 1887 another eruption of long duration occurred beginning in July and ending in March. The activity July 8, 1886, and February 22 and 27 and March 1 and 9, 1887, was more violent. There was constant emission of ashes forming into dust-clouds and falling on the neighboring towns of Camalig and Guinobatan, sometimes so darkening the atmosphere as to require artificial lighting for a few hours. Red-hot rocks rolled down the slopes almost constantly, and on one occasion the whole summit appeared to be on fire. The deposit of ash in Guinobatan reached a thickness of 3 millimeters. December 15, 1888, there were two eruptions of ashes accompanied by roarings and rumblings. September 10, 1890, small flows of incandescent material were noted on the eastern slopes. Toward the end of the month the activity was more violent with a considerable amount of ashes thrown to immense heights, and flows of molten materials and incandescent rocks reaching almost the base near the town of Libog. The following year, 1891, from October 3 to 18 there were eruptions of ashes and much molten material was extruded.

The eruption in 1892 lasting from February 3 to 29 was described as having been preceded by light earthquakes the year before, and consisted of explosive ejections of ashes, lapilli, and bombs from the crater with electric lightnings, subterranean roarings and rumblings, and flows of incandescent rock materials from the crater. It was one in which greater activity was shown, and many inhabitants in fear left the towns of Libog and Camalig. According to reports, during January it was noted that the quantity of ash-clouds was greater than in the usual emissions. February 3 a glow was seen at the summit. In the evening of February 9 small flows of lava were seen

trickling down the slopes, and on the 21st the activity was in full blast with great quantities of ash-clouds, and incandescent materials rolling down the eastern slopes. On the 24th emissions of ashes were made every fifteen or twenty minutes and explosive ejections of bombs and lapilli could be seen clearly from the lowlands. The ejections of volcanic materials continued on the 25th and 26th, and at 10 p. m. the 26th a huge column of dust-laden vapor rose from the crater and electric discharges darted back and forth. The activity with the accompanying roarings and rumblings continued through the 27th and the 28th, but after the 29th the activity grew more or less quiet. It is reported that the cone lost 100 meters during this eruption.

The following year, 1893, another eruption occurred lasting from October 3 to 23. This eruption exhibited the same manifestations as one the year before—emissions of ashes, lapilli, and bombs with accompanying roarings and rumblings, and again molten materials descended the eastern slope. An important event of this eruption was the tremor, fairly strong and of long duration, felt October 11 and October 18. During July and August, 1895, there were slight eruptions. Indistinct roarings and rumblings were heard, and some materials were ejected from the crater but fell back into it, and the flows of incandescent materials on the slopes were slight. The following year, 1896, in August and September slight eruptions occurred with similar manifestations as the ones in the previous years.

The most destructive eruption of Mayon since 1814 occurred June 25 and 26, 1897. The premonitory signs were definite and pointed clearly to an impending disaster. May 13, 1897, a strong earthquake was felt in the region of Albay and neighboring provinces and from the data presented in Table 5 it may be inferred that the movement was along a seismotectonic line extending from Guimaras Strait through Masbate, northwest of Samar, and San Bernardino Strait. The Monthly Bulletin of the Weather Bureau for October, 1897, shows that this earthquake was recorded in Europe. Father Sederra Masó doubts if this earthquake can be related to the eruption of June, citing the fact that many strong earthquakes have occurred in the neighborhood of Masbate at different times without showing any relation either to the activity of Mayon or to that of any other volcano in the vicinity. It is possible, however, that earth movements of a tectonic character may provide passages for the flow of molten lavas.

TABLE 5.—*Terremoto de 13 de Mayo de 1897* [a]

Estación.	Hora.	Clase de movimiento.	Intensidad escala I-VI.	Dirección.	Duración.	Observaciones.
Albay.......	7h 44m p. m.	De rotación y oscilación.	IV	N.-S.	30 s	Empezó con movimientos rotatorios, siguiéndose después las oscilaciones.
Tabaco......	7h 45mm p. m.	De oscilación.	III	N.-S.	30 s	Crugían las maderas; las puertas se movían mucho.
Masbate....	7h xm (minutos ántes de las 8.)	De oscilación y trepidación.	VI	......	......	Este terremoto llenó de pánico a los habitantes de Masbate. La circunstancia de ser allí de madera casi todos los edificios hizo que los desperfectos no fueran de consideración, evitándose así las desgracias personales. La iglesia parroquial de la Cabecera, el pantalán y algún otro edificio sufrieron las naturales consecuencias del fenómeno (I). Aunque no se precisa la duración de éste, dícese, con todo, que afortunadamente no fué mucha.
Calbayog....	Cerca de las 8 p. m.	De oscilación.	III	......	30 s	
Cápiz......	Xh (entre 7 y 8 p. m.)	....id....	III	E. O.	25 s	
Calivo (N. de Panay)..	.....id.........	....id....	II	......	......	
Iloílo.......	.....id.........	....id....	I	......	......	

[a] La erupción del volcán Mayón en los días 25 y 26 de junio de 1897. Manila Observatorio (1898) 55 pp.

It cannot be definitely stated that the earthquake of May 13, 1897, had any relation with the eruption of June, 1897. However, Coronas (6) records that immediately following the earthquakes of May 13 it was noted that dust-laden vapors began to appear at the crater and small quantities of lava and molten materials began to descend the eastern slopes in the direction of Libog. During the remaining days of May the glow at the crater was clearly visible at times and there were subterranean noises. Slight earthquakes were felt May 22 and 27 and June 1, 2, and 4. After the tremors of June 4 the glow at the crater remained

visible at all times and June 21 there were heard unusual noises, forerunners of impending disaster. June 22, 23, and 24, emissions of ashes and molten materials kept increasing in quantities, the while subterranean roarings and rumblings were heard incessantly. June 24 found Camalig enveloped in a cloud of ash, which darkened the whole town. The most violent phase of the activity began in the afternoon of June 25 and lasted for seventeen hours. Not only were there huge columns of dust-laden vapors emanating from the crater, and great quantities of molten lava, incandescent rock materials flowing in all the barrancos in the direction of Libog, but volcanic bombs and lapilli were being thrown into the air and were falling on the slopes amidst flashes of electric lightning zigzaging in all directions. The incandescent rock materials following the depressions and the drainage lines swept everything before them and did not stop until they had reached the shores of Albay Gulf. Barrios of Libog were completely overwhelmed—San Isidro, San Antonio, Santo Niño, San Roque, and Misericordia, and part of San Fernando, also the barrio Bigaa of Legaspi. A ridge in front of Libog serving as a wedge divided the flow of the volcanic materials into north and south branches, thus saving the convent and the town hall and the school of Libog from the effects of the volcanic flow. It was reported that ashes fell within a radius of about 80 kilometers although the amounts varied in different places. At Tabaco the deposit had reached a depth of 50 centimeters in twenty-four hours, while at Tiwi it was 15 or 20 centimeters, and at Virac, Catanduanes Island, it was 6 centimeters. At Legaspi and Daraga the fall of ashes was 1 or 2 millimeters or less. Small lapilli were reported to have fallen in Camalig and Ligao. The explosions of this eruption and the subterranean rumblings were heard at great distances. Reports from Tayabas and Camarines Norte tell of distant noises heard in those places June 25 and 26 even before it was known in Manila that Mayon was in eruption. Reliable estimates place the number of victims of this eruption between 200 and 300. Most of the deaths seemed to have been caused by hot blasts and from the rolling incandescent materials.

Mayon was again in eruption March 1, 1900, but the activity was less violent. Red-hot rock streams flowed from the summit and there was constant roaring and rumbling. It was reported that all the houses in Ligaspi were shaken, and doors and windows rattled during the explosions. The column of dust-laden

clouds rose to the imposing height of about 8 kilometers, and when the materials fell there was slight darkness. A small quantitiy of ashes fell in the neighboring towns.

The foregoing brief review of the eruption of Mayon about which we have any written record reveals many interesting features. The sections which have always been the scenes of destruction are the east and south, while the north and west have suffered very slightly. Most of the deaths have occurred on the slopes and at the base within a radius of 10 kilometers from the crater. The eruptions have been characterized in the main by explosive ejections of ashes, sometimes in great quantities, previous to outpourings of lava from the crater.

ERUPTION OF 1928

From 1900 to 1928, a period of twenty-eight years, Mayon Volcano remained apparently inactive, at least steam vapors were not noticed emanating from the crater. Agents of erosion had deepened somewhat the barrancos, the crater had become a little disfigured, and materials from the sides had begun to accumulate at the bottom. It was the longest rest period Mayon had had during the last one hundred fourteen years of its eruption history. The rest was so long that Chester A. Reeds writing in Natural History for May-June, 1928, remarked that "in all probability the next eruption will be exceptionally violent."

The 1928 activity of Mayon Volcano may be said to have begun some time in January. Persistent reports of underground roaring and rumbling reached Manila from Legaspi. There were conflicting reports regarding "smoke" from the crater. At the instance of the Provincial Governor of Albay, Father Saderra Masó, assistant director of the Weather Bureau, and the writer went to Legaspi for study and investigation. The party spent one week in the vicinity of the volcano but, on account of the bad weather conditions, was able to make observations only two days. It was noted that there was a feeble emission of steam from the crater, scarcely visible except with strong field glasses, without any pressure from behind, and the vapors disappeared as soon as they reached a short distance above the summit. Reports from ex-Governor Betts and other residents of Legaspi state that this feeble emission of water vapor continued, with more or less interruption, during the following months. Finally, about June 16, the emission of vapors assumed greater propor-

tions and in the evening of that day residents of Libog claimed to have seen a glow at the summit of the volcano.

The following week was filled with confusing and inconsistent reports. While press correspondents at Legaspi were filling the Manila newspapers with reports of "subterranean noises and huge columns of smoke from Mayon," other people were sending in news of no smoke and no eruption. It was difficult to judge the state of activity from the telegraphic dispatches from Legaspi. This state of affairs was brought to a head June 24, when clouds of condensed steam rose from the crater, apparently dust-laden, and hung over the summit, showing that Mayon was once more entering into a period of activity. From that time there was no longer any doubt as to the activity of Mayon, and throughout the Philippine Islands reports from Legaspi were anxiously awaited.

The writer left Manila at noon June 26, and reaching Pamploma, Camarines Sur, early in the morning of June 27, saw Mayon with an unmistakable pinnacle of eruption clouds silhouetted against the horizon. The vicinity of the volcano was reached about noon, but rain clouds had enveloped the upper half of Mayon and it was impossible to make out what was transpiring behind the screen. A trip was made around the volcano in an attempt to discover some premonitory signs of a destructive volcanic eruption. With the exception of faint explosive reports, scarcely audible even in the more or less deserted town of Libog, nothing was observed that might have indicated an approaching destructive eruption.

Toward evening, as the sun was disappearing behind the western horizon and darkness setting in, the crater became cleared of all obstructions and a volume of steam could be seen emanating from it, forming a "cauliflower" structure some distance above. The clouds immediately above the crater were pale crimson, due to the reflection of the glowing lava within the crater.

At exactly 6.40 p. m., June 27, 1928, the first incandescent material was seen rolling down the eastern slope in the direction of Libog, at first small and tearlike, but gradually increasing both in size and in recurrence. The view at kilometer 9 on the Legaspi-Libog road was imposing and awe-inspiring. There was the famous Mayon silhouetted against the clear sky, showing the curve of its slope, the symmetry of which has been the subject of universal comment. At the summit was the small

crater filled with bubbling lava. Clouds of condensed steam hung above, lighted by the glow of the molten material. Occasional bursting of the bubbles caused fragments of material to be shot into the air. The reports of the explosions which blew out the lava could be distinctly heard. The materials ejected were of all shapes and sizes (some pieces probably weighed hundreds of kilograms), but only a few fell outside the crater. As activity within the crater increased the bubbling lava boiled like a viscous liquid and began to pour out through the notches on the sides of the crater, at first following the ravines and gullies, forming snakelike trickles radiating from the summit. The molten material crusted over and cracked, and as glowing-hot rocks hit against each other smaller pieces of incandescent material were broken off and shot into the air—all of which, with the lines of red-hot rock streams, formed a spectacular pyrotechnic display.

The activity increased during the night, though not to an alarming point. The incandescent materials descended first about 300 meters below the crater, then 200 meters lower, and continued to push their way lower and lower until finally, at about 4 a. m., June 28, 1928, the molten rock had reached a point about 1,000 meters below the summit. Toward daylight the spectacular display apparently ceased, as the incandescence could no longer be seen; but the steam and vapors emanating from the crater and the sides and along the paths of the incandescent material bore direct evidence of continued activity.

Throughout Thursday, June 28, 1928, reports of explosions within the crater were clearly but faintly heard at irregular intervals. Condensed clouds of steam together with other clouds hung over the summit and presented a threatening aspect. Late in the afternoon an unusual outburst of fine material (volcanic dust and sand) filled the otherwise white clouds, turning them black. As these black clouds swept down the sides of the volcano some 300 meters below the summit in the direction of the barrio of Bigaa, Legaspi, the inhabitants of the district were seized with a panic. Men, women, and children seeking safety, ran pell-mell, carrying what little belongings they could gather together on the spur of the moment, driving before them in all directions the domestic animals filling the air with shrieks and howls—a veritable pandemonium.

Two unusually deep ravines from the summit met about 1,000 meters below the crater in a large hollow which began to fill with molten material; the glowing rocks remained incandescent for

some time. Toward evening sufficient material had accumulated in the depression to give it the appearance of a subordinate crater. Streams of red-hot rocks continued to roll down the eastern slopes forming in their advance a tumble of igneous bowlders which, upon addition of more material, slowly crept toward the lowlands. July 1, 1928, the front had reached more than 1,200 meters below the summit. The outflow of incandescent material continued with more or less regularity, although on certain days, notably July 5 and 6, comparatively small amounts were observed.

Mayon continued to belch forth vapors and gases, which hung over the summit in clouds. An official report from the Philippine Constabulary, dated July 9, 1928, tells of heavy black "smoke" from the crater July 8. This was of course due to the very fine material (volcanic dust and sand) which was being blown into the condensed clouds of white steam. Explosions within the crater were said to be louder though they occurred at longer intervals. Apparently Mayon had entered into another period of more violent activity. There were several explosive eruptions Sunday, July 8—namely, at 10 a. m., 5 p. m., 10 p. m., and 11.30 p. m. During these eruptions there were violent extrusions of fragmental materials of various sizes into the air, and roaring and rumbling, and incandescent materials rolling down the slopes. The eruption at midnight was accompanied with brilliant fireworks display, and the black clouds formed umbrellalike silhouettes. There were times between explosions, as was the case at 6 p. m., when the crater showed no emission of vapors.

The activity subsided somewhat during the week following. There were less rumbling and the flow of incandescent materials was slight. Apparently it was only a preparatory period. July 16 a telegram from Governor Locsin to the Weather Bureau stated that volcanic materials had begun to descend toward the northeastern slopes and that there were violent extrusions of fragmental materials from the crater between 11 and 12 p. m. The people in the neighborhood began to notice that the roaring, rumbling, and hissing noises, loud cracking, tumbling, colliding, and apparent unloading of heavy rock materials took place every three or four hours, sometimes five hours, and that the occurrence was periodic though not necessarily rhythmic. The most violent phase of the activity had begun. The culmination was reached July 20. At intervals the previous day, heavy columns of dark vapors surged straight into the sky. The activity increased somewhat July 20 and in the evening there was a spectacular

display of incandescent materials, bombs and lapilli describing parabolic curves from the summit, a column of heavy dark clouds above, the top of Mayon fire red, streams of red-hot rock materials flowing apparently in all directions. There was an incessant flashing of brilliant lightning from dust-cloud to dust-cloud and from the crater in all directions. It was an imposing sight and terrifying. The people were in a state of nervous fear.

The violent activity continued until July 23. There were periodic manifestations of imposing columns of dust-laden vapors moving spirally and towering above the surrounding regions. At times, when the wind did not make possible the towering columns, "the volcano appeared like a gigantic locomotive puffing on a heavy grade." One of the best examples of these huge columns of gas and ash rolling upwards after a fashion from a constricted orifice was observed at 6 p. m. Sunday, July 22.

In order to review the mechanism of the emission of these huge columns of dust-laden vapors a party consisting of Father Selga, director of the Weather Bureau; W. L. Bowler, of Legaspi, and the writer decided to camp near the front the lava flow and watch for an emission. The emissions had been occurring at intervals of four and five hours, and at 9 a. m. July 23 we were rewarded with one of the largest displays of the volcanic ejections of ashes. The emission was constant; steam vapors with their load of ash rolling upward in succession of circular rings moving clockwise gave the appearance of a ropy structure to the whole column. The column was fearfully black and the circular rings were apparently of the same size until high up in the column they began to spread umbrellalike. These imposing columns had been estimated at various times and by various persons, but probably the most reliable determination was the one made by officers of the United States Coast and Geodetic Survey Ship *Fathomer,* which was working in Lagonoy Gulf. They determined the height of the column on July 20 as 8 kilometers from the summit of the cone. After the energy pushing the column upward was exhausted, the materials in the clouds began to drop, and a heavy curtain of dust and ashes hung around us and darkened the atmosphere. The west wind blew the mantle in the direction of Libog, Bacacay, and Malilipot and in less than an hour we were out of darkness and ready for another observation.

These periodic emissions of dust and ashes had caused showers of fine materials within a radius of 40 kilometers, as far as the town of Virac, in Catanduanes Island. The fall was not particularly heavy, but the materials that had fallen July 19 and 20

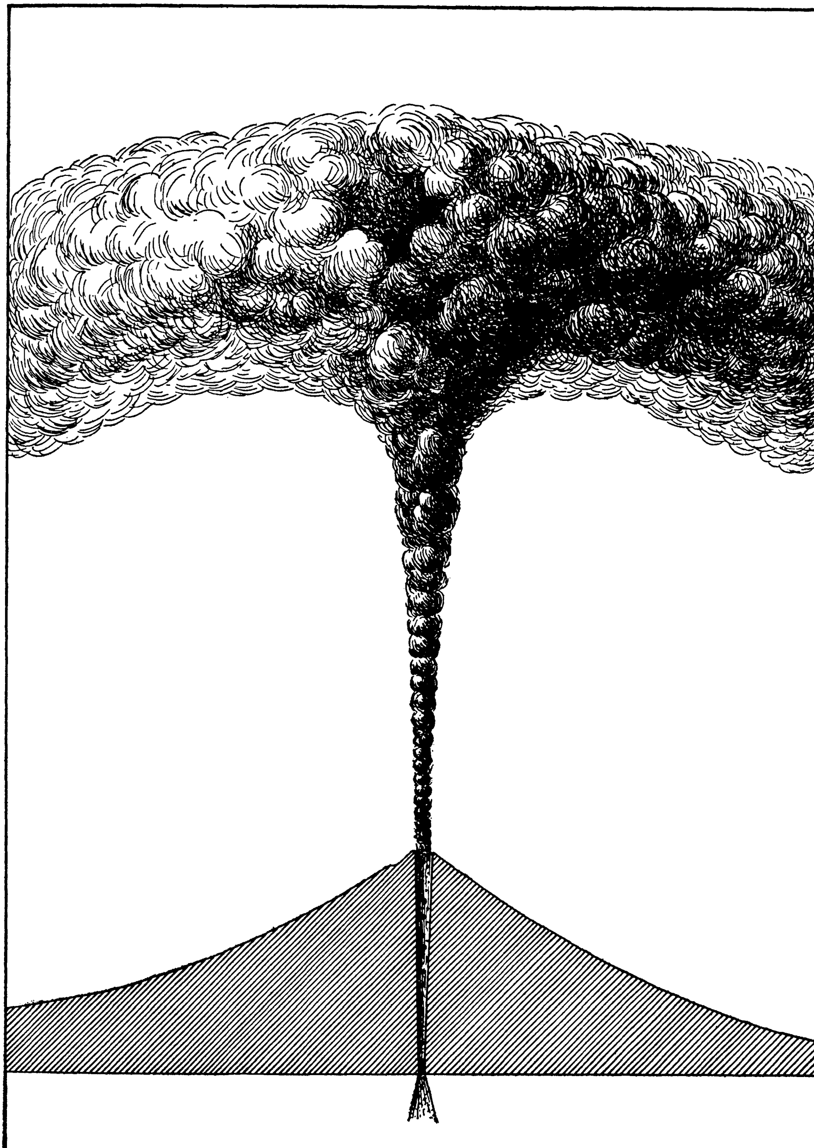

FIG. 3. Sketch drawn to scale showing the relation between the cone of Mayon and the towering column of eruption clouds spreading at the top during one of the periodic outbursts. (Modified after Perret.)

and the days following damaged the green vegetation on the southern and southeastern slopes of the volcano. Leaves of the abacá plants, between Daraga and Camalig in particular, wilted and turned brown, later with black spots. Acacia, santol, and pilli trees lost most of their leaves, the cogon and other grasses on the slopes including bamboos turned burnt-brown. The damaged area extended in a belt about 7 kilometers wide starting a little south of Guinobatan and swinging around the base of the volcano through Camalig and Daraga and portions of Legaspi across the barrios of Bigaa and Rawis of Legaspi to Libog, Malilipot, and Bacaycay. A great number of trees and bamboos in Camalig, Daraga, and in the barrio of Bigaa, Legaspi, had the portions facing west and away from the volcano brown and wilted; the portions facing the volcano were green and apparently unharmed. The selection of portions damaged was due to the direction of the wind.

The flows of molten lava from the crater and the rock materials which were sometimes half-fused, incoherent, and fragmentary followed at first two or three distinct ravines and barrancos, but after these were filled and had built up they formed ridges and the former ridges or hogsbacks became the depressions. After the main depressions were filled, the flows from the summit became more or less general, all, however, taking the direction of Libog or a little to the north and south. The different lines of descent were well marked during the day by dust clouds following the incandescent or half-fused materials shooting downward on the slopes, and at night by the glow and glitter of red-hot rocks. The following is a description by Dr. H. W. Wade, director of the Culion Leper Colony, who with W. L. Bowler, of Legaspi, and Frank W. Sherman spent July 27 and 31, 1928, on the slopes of Mayon Volcano for observation of certain features of the eruption:

Because they are heaped considerably higher than the general level of the ground beside them, it is not at first evident, at least in some cases, that these ridges follow the course of small ravines running fairly directly down the side of the mountain. It could be thought that they are meandering down on fairly level ground, as it could be thought that a ship resting on quiet water is flat-bottomed. Actually, the pile has a keel. so to speak, that fills a small ravine.

To the novice these ridges seem merely piles of rock and rock fragments. It is difficult to realize at first that they are, in effect, rock glaciers. Standing beside one of lesser activity, it might be supposed that the occasional slide of small material that rattles down the side of the rock

ridge, and the rolling down of a massive bowlder, is due solely to the tendency of heaped-up loose material to attain a stable slope-angle, for the angle of the sides is usually 45° or greater. But if the effect of falls at a given point be watched long enough it is realized that the slope does not become less, that the place left by such falls is gradually taken up, that the falling is due to the forcing outward of material by pressure within. This pressure, obviously, can come only from far above, where the mountain slope is greater and where new material is constantly being added.

Unavoidably, the falling down of material at the sides of the ridges tends to broaden them out, but in the main this seems to be very slow. Ground countours and the accumulation of larger rock masses at the base of the sides may tend to inhibit broadening. However, it seems probable that the main factor is that, due to the character of the material, most of the force is transmitted along the axis of the slide, and that weight of the mass tends to overcome the lateral pressure. In other words, there is a tendency to establish a lateral equilibrium, so to speak. When this is approached falling at the sides becomes less and less frequent, though at the end of the slide it is still more or less active and the slide as a whole continues to progress downward.

Such was the case with the ridge, a lateral stream somewhat out of the line of direction of the main flow, beside which our party camped on our first night on the mountain. When we first reached it the mass, towering sharply some 50 feet above us on the same ground-level, and correspondingly farther up the hill, was very impressive. Every few minutes, somewhere along its length, a mass rolled down the side, sometimes reaching the bottom entire, sometimes smashing into fragments. In either case, though it was full daylight, red was usually seen somewhere, either in the falling mass itself or in the place from which it came, and often along the course of its fall. Once in a while a momentary flicker was seen, as if of a bit of flame, but from prolonged observation at night, when so much red is seen that nearly every fall is something of a spectacle, the writer is very doubtful that there is any real flame; a splash of powdered fragments of the red-hot material may cause the illusion of flame.

It is not to be understood that there is no flame in connection with these slides. It is easily seen at night from the road below. But this is due to red-hot material setting fire to the grass and other vegetation along the sides of the slides.

At first the party did not seriously consider spending the night beside the slide, with a difficult crossing to be made to get onto the safe side of the ravine in case of need. But as the hours passed and the slowness of change was realized, and after exploration of the ground-contours under the 10-foot elephant grass uphill from us, it was decided that it was safe to stay there, where the night spectacle of the slide beside us would be so much more impressive than from the lower ground across the ravine. The decision was fully justified by the course of events. No one of the party would have missed the experience, in spite of the fact that camp was moved at about 2 a. m. This was done because, during and after an hour's noisy blow-off by the mountain, the flow on the upper slope in-

creased greatly, and with sense of perspective impaired by the darkness the party came to fear that escape might be cut off by filling of the ravine to be crossed. Four days later there was no very great change at this point on the mountain. The slide had not widened materially; the camp site was about as far from being covered as when we first reached it.

But though this ridge was but slightly active, comparatively, its lower end did progress, and at the second visit it was probably not less than 100 yards farther down than at first. On the first visit a series of photographs was taken of the end, to illustrate the mode of progress. Two rather large heads of rock stood out at the moment, these evidently in rather precarious equilibrium. At brief intervals material fell, sometimes a flow of fine stuff, sometimes rocks, as the one that stirred up the dust. In the few minutes that the flow was watched from this vantagepoint, the nearer of the two heads fell, or at least lost its top, with a roar of falling stuff and a dense cloud of dust. Close comparison of the knobs shows that the mass rotated as it fell; the picture was taken as it was going over. The mass of dust and sandlike material seen shooting up was due to the fall of rocks the dislodgement of which caused the upper mass to fall.

The dust that arises with every fall of rock is one of the interesting features, at least to one who is within range of it. Looking at the rock slides from Legaspi, or from the road at the foot of the mountain, it looks like smoke, and many think it to be that. In places where movement is most active, as in the tremendous pile, which moved downward, we believe, at least a half kilometer during our second night on the mountain, the illusion of a smoking, burning pile is perfect. However, though the rock mass is red-hot a foot or so under the surface, there is no sign of any such emanation from it when there is no disturbance of the surface by falling material, though some may arise in a strong gust of wind. Neither by sight nor smell was the writer able to convince himself that there is any smoke in it; certainly it is mainly, and I believe it to be solely, powdered burnt rock. The odor, it was said by a member of the party, is similar to that arising in a foundry when molten metal is poured into sand molds.

The dust is by no means impalpable. Carried by the wind it gets into everything. One's eyes are full of it, one's teeth grit with it; it gets into the works of one's camera and one suspects its presence within one's watch. For the skin it seems to have an abiding affinity!

The writer believes that much of the "smoke" given off from the crater during a period of eruption (a "blow-off") is of the same nature. Certainly it must contain more or less of it. On several occasions during eruptions we heard a sound as of rain falling sharply on the grass about us, caused by showers of coarse particles. However, the emanation from the crater is probably not a single material. During some eruptions voluminous, dark clouds are given off, but on other occasions it is much less voluminous, so far as the eye can determine, and pale. On one occasion we were showered, apparently from the crater, with impalpably fine material that fell in particles that splashed on landing, as do heavy wet snowflakes. Nothing just like this was seen about the slides.

Samples of rock material from the 1928 eruption were analyzed by Gil O. Opiana, assistant chemist, Bureau of Science.

TABLE 6.—*Analysis of material from the 1928 eruption.*

	Per cent.
Silica (SiO_2)	50.25
Alumina (Al_2O_3)	18.95
Ferric iron (Fe_2O_3)	4.90
Ferrous iron (FeO)	4.19
Phosphorus pentoxide (P_2O_5)	0.34
Titanium oxide (TiO_2)	0.89
Manganous oxide (MnO)	0.14
Lime (CaO)	9.60
Magnesia (MgO)	4.00
Potash (K_2O)	1.38
Soda (No_2O)	5.19
Chlorine	0.06

From the analysis it may be noted that the silica content is about 50 per cent, hence the rock may be properly termed basic. Had the rock been the only extrusive material from the volcano and had it escaped from the crater as a fluent, smooth, ropy lava of the pahoehoe type, being highly basic and very mobile, it would have spread to a great distance before solidifying, and a Mayon with more or less flat slopes would have resulted. The flow of molten material from the summit of the volcano has been a subject of frequent discussion, particularly among those who witnessed the last eruption.

Von Drasche(7) writing on Mayon concluded that small lava flows had been erupted from the summit. Abella(1) maintained that great amounts of lava, although fragmentary and incoherent, flowed almost constantly during periods of activity. Coronas(6) in his report on the eruption of 1897 included several figures of that and of previous eruptions in which the supposed path of lava flows from the summit of the volcano was outlined in red. Adams and Pratt(2) in their reconnaisance of southeastern Luzon expressed the opinion that probably molten lava issued only from near the summit and seldom descended more than one-third of the slope before cooling.

The writer was at the volcano at the beginning of the 1928 eruption and made observations during the course of the eruption, and, knowing the different opinions regarding this phenomena, directed particular attention to this point. There is an element of truth in all the foregoing statements. As has been remarked the main framework of Mayon Volcano consists of layers of lava flows and fragmental materials. During periods of activity several kinds of materials are extruded, principally half-fused materials from the crater walls and molten lava. There were times when fluid lava could clearly be seen flowing from the main chute

in small intermittent streams. The molten lava cools very quickly and, after passing through the steep descent, piles up and generally takes the form of the cindery scoriaceous, or the *aa* type of lava. There were times when the emission consisted largely of solid angular blocks, and half-fused materials, and very little or no molten lava.

August 1, the main stream of these rock materials had forked at a 600-meter elevation into a northeast branch and a southeast branch. The tumble of rock materials at the front had every appearance of a terminal moraine in glacial regions. The loose materials, some half-fused and incandescent, some scoriaceous and cindery, incoherent and rugged in outline, were lying at the angle of repose in a ridgelike formation toward the lowlands. Secondary transitory fumaroles developed on these lava streams, and, according to Father Selga's records, some attained a temperature of 320° C. These materials advanced, following ravines and gorges, and kept on their journey to the lowlands during the months following. In October and November these igneous bowlders of varying sizes and shapes covered portions of the railroad tracks and the provincial road between Legaspi and Libog. On the western slopes the lines of rock streams had reached to about 1,000 meters elevation, although they were mere rivulets compared to the main flows.

The emission of gases and dust from the crater continued during the first half of August but with decreasing violence and display. The roaring and rumbling gradually disappeared and the lines of glowing rocks at night became less and less distinct so that by the end of August the present eruption may be considered to have terminated. Aside from the streams of rock materials in the direction of Libog, and the barren slopes, and the somewhat different shape of the crater, nothing in the neighborhood bears evidence of an eruption. The trees and plants damaged in July have recovered and once more the plains and slopes of Mayon are covered with green vegetation. The people have returned to their homes, and the disturbance which caused no little commotion and mobilized all the government forces and the Philippine Chapter of the Red Cross has settled down—to wait for the next eruption.

CHARACTER OF MAYON'S ERUPTIONS

During the one hundred fourteen years of Mayon's history following the destructive eruption of 1814 we have a record of at least twenty-eight distinct eruptions, an average of one eruption every four years. The longest periods of apparent inac-

tivity were from 1900 to 1928, a period of twenty-eight years, and from 1814 to 1827, a period of thirteen years. From 1885 to 1900, fifteen years, Mayon was more or less constantly in eruption except in the years 1889, 1894, 1898, and 1899. It is apparent that the normal state of Mayon is one of continuous mild activity, and that the long periods of rest followed the most violent eruptions. The thirteen years following the eruption of 1814 was the second longest period of inactivity, and the years following 1897 with the exception of a small eruption in 1900 were marked with no activity. This may be explained by the fact that after a period of violent activity it must take a longer time for replenishing of stock and resumption of activities. The shape and form of the cone of Mayon bear mute evidence that its eruptions have never been violent enough to cause destruction to the form, and that the volcanic conduit has always been in the center. Most of the eruptions have been merely to patch up incisions made by agents of erosion.

In the discussion of the premonitory symptoms of Mayon's violent eruptions, which caused much destruction to life and property, the eruptions of 1814 and 1897 are taken as basis. The violent eruption of February 1, 1814, was preceded by local earthquakes the day before, which were continuous during the night. The violent eruption of June 25 and 26, 1897, was preceded by strong earthquakes in Albay and the neighboring provinces, and continuous local earthquakes were felt May 22 and 27, and June 1, 2, and 4. On June 22, 23, and 24 subterranean roaring and rumbling, which might be compared to artillery discharge underground, kept increasing in intensity and violence as the crisis was approached. According to one resident of Libog the springs which supplied their drinking water failed previous to the violent explosion. Both eruptions were marked with violent activity in the emission of gases and dust from the crater. The extrusion of immense columns of dust is the most constant of these premonitory symptoms. The eruption of July 13, 1853, lasted only one afternoon but caused the death of thirty-three persons. This violent eruption was preceded by loud subterranean noises without local earthquakes, followed by the sudden emission of gas and ash and incandescent materials so suddenly that the people on the slopes were caught unawares.

Von Drasche(7) in defining the characters of the eruptions of Mayon adopted Stohr's hypothesis of three periods in the life history of a volcano as follows: First, lava flows;

second, agglomerate flows; and third, eruptions of ash. According to this life history von Drasche believes that Mayon is in the second stage, though Abella(1) strongly opposed this opinion. The writer agrees with Becker(5) that there could hardly be such regularity in the life history of a volcano, and that while some volcanoes may have followed the succession of events as implied in the hypothesis there are others which have not shown any indication of regularity. It must be remembered that Stohr's hypothesis refers to the different stages of the life history of a volcano and not to the different phases of an eruption period. For a classification of these different phases of a volcanic eruption, Perret in his description of the Great Eruption of Vesuvius in 1906 [5] divided them into the luminous, liquid-lava phase; the intermediate, gas phase; and the dark, ash phase. The luminous, liquid-lava phase refers to the glow of the molten materials in the crater at the beginning of new activity, while the dark, ash phase refers to the culminating stage of the eruption. In the case of Mayon the luminous, liquid-lava phase is of short duration, the intermediate gas phase, characterized by vapors and gases with but little ash, is longer. The dark, ash phase is characterized by the preponderance of ejected, ash material.

It is well known that the immediate cause of volcanic eruptions is the explosive force of pent-up steam and that the gases are the chief eruptive elements. The supply of these gases has been assumed to be at some unknown depths and the source is the magma itself or the surrounding materials of the lithosphere, the wall rocks.[6] The periodic and irregular evolutions of gas at the upper extremity of the volcanic conduit which result in spasmodic activity may be assigned to the manner in which the gases reach the topmost lava inside the crater. Even if the supply of gases from the sources were uniform there would be a difference in the amount reaching the top of the volcanic conduit on account of the irregularities in the process of transmission and diffusion. During periods of repose the topmost lava solidifies, and the gases accumulate beneath. As soon as the gases acquire sufficient energy, they explode their way through and dust clouds result.

The topmost lava being thus blown into fine dust and ash, the lavas from the deeper parts of the column come up and

[5] Carnegie Institution Pub. No. 339 (1924).

[6] Iddings, J. P., The Problem of Volcanism, Yale University Press (1914) 246–555.

these materiales are exuded through the notches on the sides of the crater. The microscopic study of these lavas shows that they are rich in augite phenocrysts. In the study of lavas from Vesuvius [7] it was found that the "rapidly-moving" lavas, of the *aa* type, are rich in augite phenocrysts, and that they "were derived from the deeper parts of the column and were composed of magma that issued highly charged with gas, hence highly mobile and capable of rapid and distant flow and complete crystallization in spite of the continuous movement." The Mayon lavas do not show complete crystallization, but the size of the crystals bears evidence, that they came from below the upper part of the column. At times small outlets are maintained and the supply of gases is likewise small and more or less uniform so that a "panache" of dust cloud is maintained for some time. The evolution of volatile gases sufficient to triturate the volcanic materials into the fine dust be tremendous, particularly so when the amount and character of the trituration of the materials and the height to which they are blown are considered. A sample of dust from the 1928 eruption collected at Libog by the detachment of the Philippine Constabulary has been separated according to sizes with the following result: Particles less than 0.589 millimeter in diameter, 78 per cent; more than 0.589 and less than 1.168 millimeters, 13 per cent; more than 1.168 millimeters, 9 per cent. Other samples collected are similar showing that a great percentage of the dust is fine material, and in order to account for the manifestation of dust-laden steam rising to 8 kilometers it is necessary to assume a very considerable length of the bore.

The volcanic dust of Mayon settling upon the surrounding country did some damage to the vegetation. The damaged areas were more in the south than in the north and northeast, although the direction of the wind was from the west and southwest. This is explained not only by the fact that the dust and ashes assumed the form of a funnel with the greatest diameter above when extruded violently from a restricted orifice, but that the winds at higher levels blew in the opposite direction. The ashes and dust upon being carried to the west and southwest were then taken up by the winds nearer the surface and deposited on the leaves of plants on the southern and eastern parts of the area. In the region about Camalig and Daraga in particular the

[7] The Vesuvius Eruption of 1906, Carnegie Institution of Washington (July, 1924) 146.

parts of some plants facing the volcano were green and undamaged, but the parts away from the volcano and facing the southwest were brown and wilted. Inhabitants of the damaged areas were not in any particular agreement whether the falling ashes were hot or fairly hot. Some claimed they were hot enough to be noticed, others did not notice any heat. The fact remains that following the big eruptions of ashes, July 20 and later dates, there were intermittent showers, and the leaves of plants turned brown and wilted. In cases where the entire leaf was not damaged they were spotted where the dust had fallen and settled down.

Samples of dust and ash were collected in the different parts of the Mayon area, particularly in those districts where damage to the plants was greatest. Portions of these samples were put on the leaves of the same species of plants damaged in Camalig and Daraga growing on the Bureau of Science grounds and vicinity under similar conditions of sunshine and rainfall. The plants were not damaged in any way. Father Selga performed the same experiment with the plants in the vicinity of the Weather Bureau with the same result. Portions of the same samples were given to the division of general, inorganic, and physical chemistry, Bureau of Science, for chemical analysis. Preliminary report showed the dust to be neutral with litmus. The final report, however, showed the material to be decidedly acid, although it could not be expected to give an acid reaction except at high temperatures.

The chemical analysis made by Gil O. Opiana, assistant chemist, Bureau of Science, of the dust collected is shown in Table 7.

TABLE 7.—*Analysis of dust from Mayon Volcano.*

	Per cent.
Silica (SiO_2)	49.11
Alumina (Al_2O_3)	21.30
Ferric oxide (Fe_2O_3)	6.12
Ferrous oxide (FeO)	2.31
Phosphorus pentoxide (P_2O_5)	0.33
Manganous oxide (MnO)	0.15
Titanium oxide (TiO_2)	0.53
Lime (CaO)	9.65
Magnesia (MgO)	3.64
Potash (K_2O)	1.14
Soda (Na_2O)	4.37
H_2O+	0.64
H_2O-	0.36

There is a detectable amount of Cl and SO_4; NO_3 is absent.

The phenomena may be explained as follows. Hydrochloric acid gas is one of the common products of volcanic eruptions, and the presence of chlorine in detectable amount, as shown by the analysis, shows that it is not wanting in the Mayon exhalation. The volcanic dust provided a nucleus for the condensation of moisture present in the air. Hydrochloric acid gas has a very strong affinity for water and is at once absorbed, so that when the dust settled on the leaves of plants it carried a solution of hydrochloric acid which caused the damage. Hydrochloric acid, however, evaporates quickly and samples taken from Mayon and brought to Manila would not give the same effect. It will be recalled that the damage to the plants in the Mayon area was temporary.

On the slopes of the volcano in the ravines and on the stream beds and on the tops of rocks the deposit of dust and ash was, of course, much thicker and in some places attained an average of 20 millimeters. During the day the front of the rapidly advancing material from the summit shooting down the ravines and gullies was marked by trailing dust-clouds. At night the glow of the incandescent materials and the occasional bursting of the fragments, simulating flames, marked the lines of descent. At times a bluish flame was observed in front and over the surface of the lava flow which might have been true volcanic flames due to the presence of inflammable hydrogen and hydrocarbons. Loud roaring accompanied by hissing noises from the moving lava flow are due to the escaping gases. The molten lava, half-fused materials, and other ejectamenta moving very rapidly on the first descent, then settling down to a clinkery flow first filled the ravines and gullies and at the end formed a tumble of rock materials simulating a glacial moraine. Upon leaving the crater the molten lava began to solidify and behaved as regular *aa* lava, advancing by overriding the already solidified portions and presenting a brittle semisolid front, irregular blocks falling from the fiery mass beneath. At the beginning of each outburst the topmost lava is shot upward as finely divided ejecta by powerful gaseous expansion. A sufficiently high temperature is maintained by chemical action to make a pasty mass extrude through the notches on the sides. This boiling over after each ash eruption is peculiarly characteristic of Mayon. During the evolution of gases and the sudden extrusion of materials, other semifused materials on the bottom and sides of the crater may be thrown, and there may be the accessory ejecta which describe parabolic curves from the summit.

In other words, the extruded materials from the crater may be molten lava, half-fused materials, solid lava, or fragmental ejecta.

The so-called cyclical interval of repose and renewal of volcanoes was well exhibited by Mayon during its last eruption. It appears that a succession of potentially explosive magma rises through the volcanic conduit, and whenever the gas accumulation has reached a maximum saturation the disturbance of the equilibrium is sufficient cause for an outburst and an eruption. There is then released energy and material which have been accumulating during a period of lesser activity, although during these periods there is temporary relief through minor outbreaks. After each outburst there follows a period of rest, which may be due to exhaustion of the supply or obstruction of the conduit or diversion of the column. A fresh supply of explosive materials from the unknown source rises and begins to accumulate beneath the topmost lava to repeat the cycle. At the beginning of each cycle the explosive magma appears to pulse in surges of increasing violence, and seems to be bent on producing dynamic paroxysms.

At 600 meters elevation the advance of the lava flow, which has been referred to as the slide, moved rather slowly. The bottom of the flow appeared to have solidified and the movement was by the half-fused, half-solidified materials overriding the solidified lobes below. At this point the rate of movement was estimated at half a kilometer every twelve hours. The slower movement was due to the lower angle of the sine curve of the slope and to the not overplentiful supply of fresh materials from the summit. September 1 the vanguard of the flow was at 500 meters elevation and was taking possession of the deep ravines and gullies. Of course, the manner of movement had changed to a mere yielding to gravitation as a result of overaccumulation.

Observations of the nature of the emission of the volcanic ejecta and accounts of the people who survived the 1897 catastrophe, indicate that most of the deaths due to Mayon eruptions are caused by falling and rolling hot rocks, and by superheated and suffocating gases emanating from the lava. It is claimed that so much gas comes from rolling incandescent material that there is no escape for a person overtaken; many persons lost their lives because they were unable to dodge the advancing gases, which have been termed *lawi lawi* by the Bicolanos. Deaths are apparently instantaneous as sometimes the victims

are found in their customary positions. Some of the bodies were charred beyond recognition.

During the present eruption of Mayon there were persistent reports that Bulusan Volcano, a neighboring volcano in Sorsogon, situated in the same belt was also emitting ash and dust. The sympathetic action between the two sister volcanoes is not proved this time as Bulusan has been emitting a little ash and dust constantly. During the 1918 eruption of Bulusan, Mayon remained quiet and did not show any sympathetic action. The Bulusan ash showed marked similarity to the ash from Mayon, but A. D. Alvir has shown that the materials from Taal and Canlaon are likewise similar.

RECOMMENDATIONS

From the nature and habits of Mayon eruptions and judging from its appearance it is clear that eruptions of greater or less violence must be expected from time to time. It is likewise clear that man has no power to prevent future eruptions. The most that can be done is to take precautionary measures to prevent greater destruction of life and property.

Mention has been made that the railroad and the provincial road cross at several places around the base of the volcano. It would be desirable to have these crossings eliminated because in the event of a violent eruption these crossings will be veritable death traps for the people fleeing along the provincial road. Even during normal times passenger-carrying trucks and other vehicles and the trains are liable to have disastrous collision at these points. To have railroad bridges over all road crossings would entail an outlay of considerable funds but it is believed that the resulting protection would be well worth the expenditure.

Certain portions of Mayon Volcano now classified as public land and subject to legal occupation as agricultural land should be withdrawn from entry. The writer has noticed on several occasions homestead notices on alluvial fans and other places directly in front of the big ravines and barrancos. Disregarding the dangers of volcanic eruptions these places are not safe on account of sand and gravel and bowlder floods which may come at any time without previous warning. There are records of floods on the slopes of Mayon which were as disastrous if not more so to human lives and property as any of its violent eruptions. It would be desirable to have Mayon declared a public park and a line drawn around the base to limit the entry

of homesteaders and others. The Bicol region has available for entry large areas of public land more suitable for agriculture, and for the protection of the people this step is considered imperative.

The establishment of a seismograph station at the base of Mayon is strongly recommended. Periodic eruptions of Mayon must be expected, and the danger of a violent eruption is not without the range of probability. It would be extremely desirable to be able to warn the people and give them sufficient time to flee for safety. It is just as much a criminal offense to tell the people to vacate their homes and their property and cause a general exodus which would cause confusion and disorder and unnecessary expense and loss of livelihood as it is not to give the warning at the proper time. It must be remembered that at the most the data for a prediction are fragmentary and every means known to science should be available and ready for use. The Government official in charge of giving the warning has no middle course to follow; he must tell the proper time to make a quick get-away, not any sooner than necessary and certainly not later. During the 1928 eruption the concentration camps were ready, and if during any of the outbursts the warning to leave had been given it could not be assured that there would be no casualties in the confusion which would have followed. The concentration camps would have been filled with people and the expenses and trouble of keeping them there would have been considerable, not saying anything about the disease and sickness usually following such hasty concentrations. The Sakurajima volcanic eruption of 1914, which Jaggar considers as the greatest in the annals of the Japanese Empire, resulted in the loss of only thirty-five lives and some millions of dollars in property.

It was through a study of premonitory earthquakes in their relation to volcanic outbreaks that the Sakurajima eruption was definitely predicted; conversely, it is hoped that, in time, through exhaustive study of volcanic activities, earthquakes may be predicted with accuracy. If such forecasting can be achieved, it is conceivable that an earthquake of the severity of the Tokyo disturbance could occur with a loss of life and property almost negligible in comparison with what actually happened in September, 1923.

The phenomena of the Sakurajima eruption, therefore, are proving of transcendent importance to the scientific world, and the measures which were taken to safeguard life at that time are being eagerly studied anew.

BIBLIOGRAPHY

1. ABELLA Y CASARIEGO, ENRIQUE. El Mayón, o volcán de Albay (Filipinas). Madrid, Tello (1885) 8° 23 pp., 2 pls.
2. ADAMS, G. I., and W. E. PRATT. Geologic reconnaissance of southeastern Luzon. Philip. Journ. Sci. § A **6** (1911) 449–481.
3. ARAGÓN, ILDEFONSO DE. Suceso espantoso y memorable acaecido en la provincia de Camarines el día 1° de Febrero de 1814. Sampaloc (1814). (Erupción del Volcán Mayón.) 4° pp. 19.
4. BARATTA, M. Eruzione del vulcano Mayon nel 1897. Bol. della Soc. Geografica Italiana, Fasc. **12** (1898) 8°, pp. 5 pl. 1. (Not seen.)
5. BECKER, G. F. Report on the Geology of the Philippine Islands. U. S. Geol. Survey 21st Ann. Rep. **3** (1901).
   BECKER, G. F. A feature of Mayon Volcano. Proc. Wash. Acad. Sci. **7** (1905) 277–282, 1 pl.
6. CORONAS, JOSÉ, S. J. La erupción del volcán Mayón en los días 25 y 26 de Junio de 1897. Manila Observatorio (1898) 55 pp., 2 maps, 2 pls.
7. DRASCHE, RICHARD VON. Fragmente zu einer Geologie der Insel Luzon (Philippinen), etc. Vienna, Gerald's Sohn (1878) 4°, 99 pp., 5 pls. (incl. 2 maps). Translation: Datos para un estudio geológico de la isla de Luzón (Filipinas): Bol. de la Com. del Mapa Geol. de España, Madrid **8** (1881) 269–342.
8. HUERTA, F. DEL. Estado geográfico, topográfico, estadístico de las Islas Filipinas. Manila, M. Sanchez, 1st ed. (1855), 2d ed. (1865).
9. JAGOR, FEDOR. Reisen in den Philippinen. Berlin, Weidmann'sche Buchhandlung **16** (1873) 381 pp., 1 map. (Der Vielkan Mayon oder Albay und Seine Ausbrüche, pp. 69–75). Travels in the Philippines. London (1875) 370 pp. Translation of the above with some omissions. (The Volcano of Mayon or Albay, and Its Eruptions, pp. 90–93.)
10. MASÓ, M. SADERRA, S. J. Volcanoes and seismic centers of the Philippine Archipelago. Census of the Philippine Islands, 1903. Washington **1** (1904) 8° 184–254, 8 pls.
11. PERALTA, FRANCISCO. Breve análisis química practicada sobre las arenas volcánicas que eruptó el de Albay, el día 1° de febrero y cayeron en la capital de Manila. Sampaloc (1814) 12° 22 pp. (Not seen.)
12. SMITH, W. D. Geology and Mineral Resources of the Philippine Islands. Bureau of Science Pub. **19** (1924).
13. ZINNG, ROBT. M. The Bicol region of the Philippine Islands with an account of the recent eruption of Mayon Volcano. Inter-Ocean **9** No. 8 (August, 1928) 433–438.

ILLUSTRATIONS

PLATE 9

FIG. 1. Looking across the crater of Mayon toward Tiwi, from the Daraga side. 1911. (Photograph by McDonald.)
2. Looking across the crater of Mayon toward Libog. 1911. (Photograph by McDonald.)

PLATE 10

FIG. 1. Looking across the crater of Mayon from the Libog lip toward Polangui. 1911. (Photograph by McDonald.)
2. Rocks at the bottom of the crater of Mayon. 1911. (Photograph by McDonald.)

PLATE 11

Mayon Volcano, showing glow of incandescent materials at night. Photograph taken from kilometer 9, Legaspi–Libog Road, June 28, 1928, 10 p. m. (Photograph by Cortez.)

PLATE 12

FIG. 1. Mayon Volcano, June 24, 1928. (Photograph by Cortez.)
2. Mayon Volcano, June 28, 1928. (Photograph by Cortez.)

PLATE 13

FIG. 1. Mayon Volcano, showing greater activity. July 8, 1928, 5 p. m. (Photograph by Photo Art Studio, Legaspi.)
2. Mayon Volcano in action. A towering column of dark eruption clouds reaching far into the sky, striking terror into the hearts of the people. July 19, 1928. (Photograph by Moderna Studio.)

PLATE 14

The weird fantastic shape assumed by eruption clouds over Mayon Volcano. July 20, 1928, 11.07 a. m. (Photograph by Photo Art Studio.)

PLATE 15

The crater cloud of Mayon Volcano. July 21, 1928.

PLATE 16

Mayon Volcano, puffing like a gigantic locomotive pulling up a steep grade. July 23, 1928. (Photograph by Moderna Studio.)

PLATE 17

Dark ash clouds covering the sky above Mayon Volcano. August 1, 1928, 5.30 a. m. (Photograph by Moderna Studio.)

PLATE 18

Advancing front of the lava on Mount Mayon, showing the character of the material. July, 1928. (Photograph by Wiley.)

PLATE 19

Mount Mayon, along one of the ravines, showing mantle deposit of volcanic dust and ash and volcanic bowlders at the bottom. July, 1928. (Photograph by Wade and Franks.)

PLATE 20

Ash cloud directly over the observers shortly after one of the periodic outbursts of Mayon Volcano. July, 1928. (Photograph by Wade and Franks.)

PLATE 21

Lava from the advancing front on Mount Mayon. Collected by Father Selga, August 29, 1928.

TEXT FIGURES

FIG. 1. Map of Mayon and the neighboring towns in Albay Province.
2. The form of cinder cones.
3. Sketch drawn to scale showing the relation between the cone of Mayon and the towering column of eruption clouds spreading at the top during one of the periodic outbursts. (Modified after Perret.)

1

2

PLATE 1. MAYON VOLCANO, ABOVE, FROM LIGAO; BELOW, FROM TABACO.

PLATE 2. MAYON VOLCANO, FROM A DISTANCE OF 15 KILOMETERS.

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PLATE 3.

1

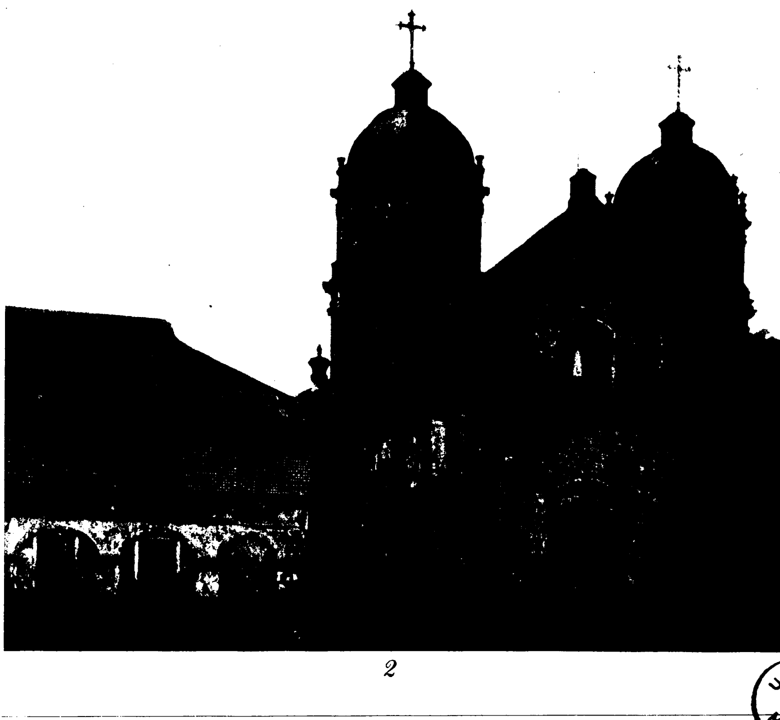

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PLATE 4.

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PLATE 5.

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PLATE 6.

PLATE 7. AIRPLANE VIEW OF MAYON CRATER, SHOWING GASES AND MAIN CHUTE.

1

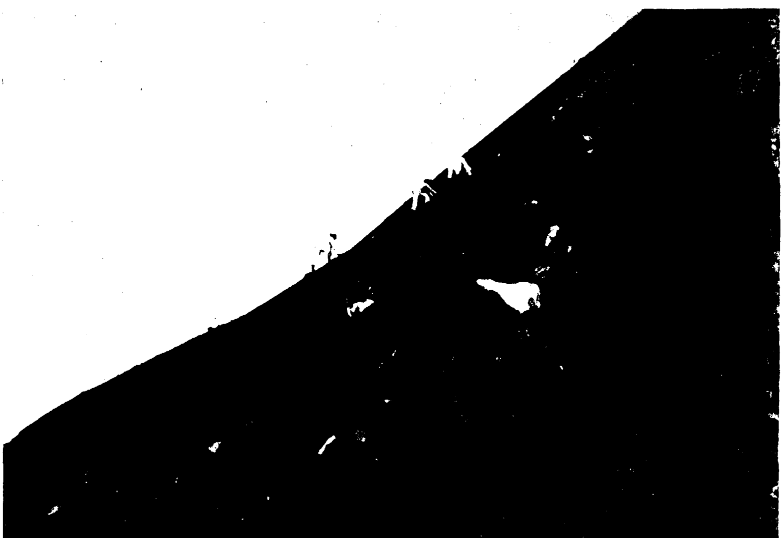

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PLATE 8.

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PLATE 9.

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PLATE 10.

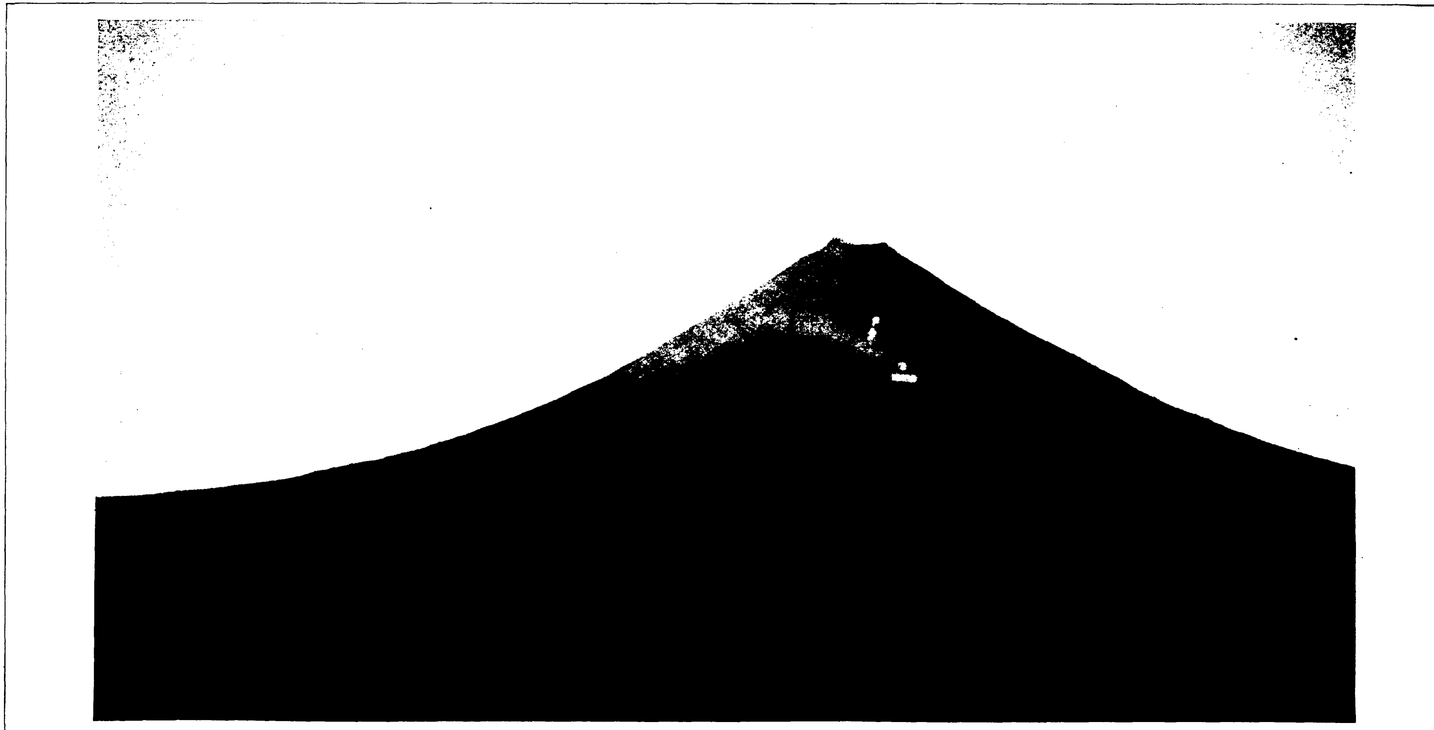
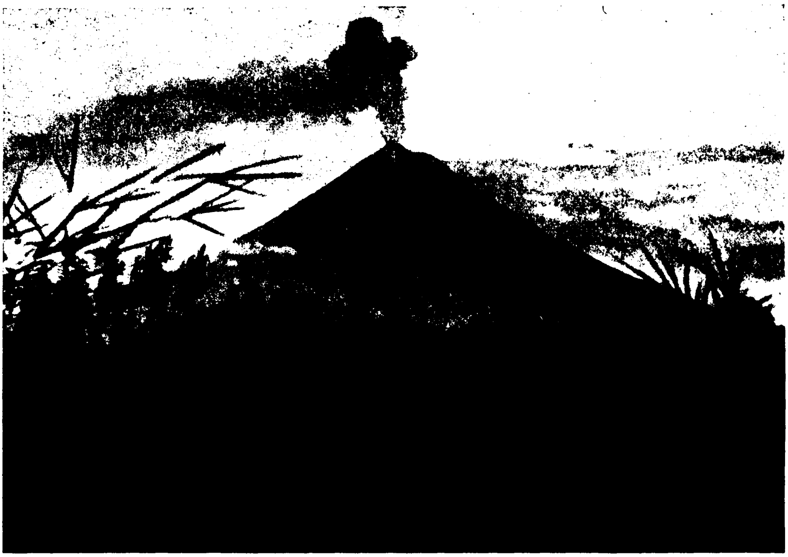


PLATE 11. MAYON VOLCANO AT NIGHT, SHOWING GLOW OF INCANDESCENT MATERIAL.



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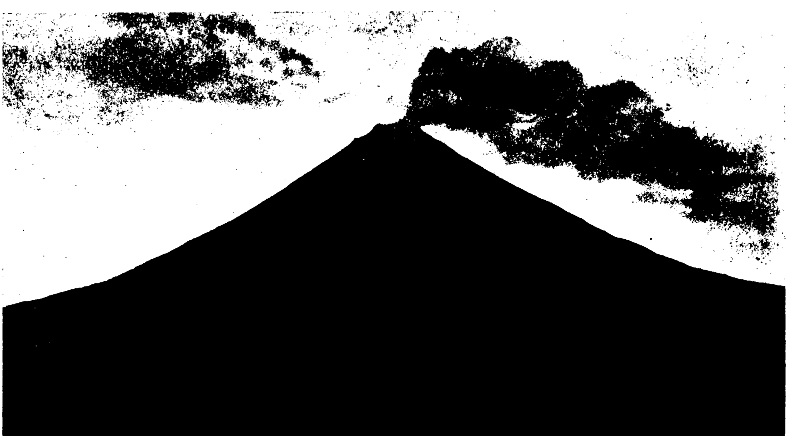

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PLATE 12.

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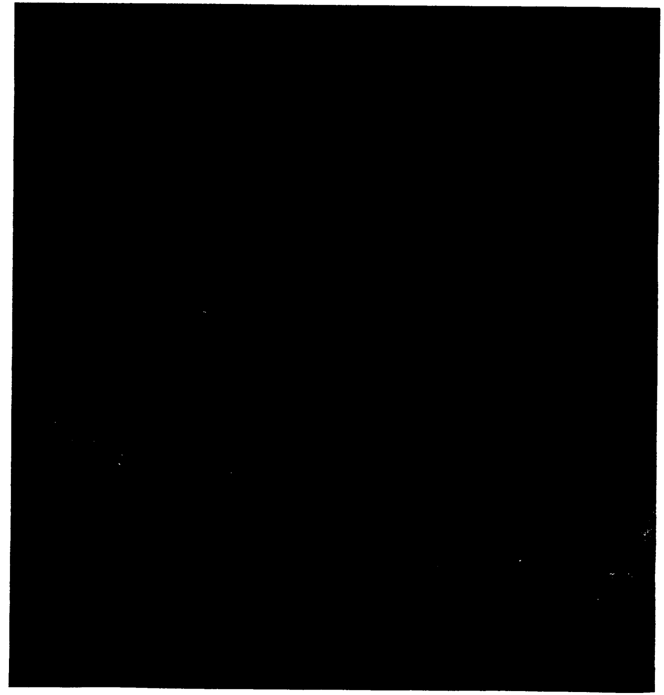

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PLATE 13. MAYON VOLCANO IN ACTION.

PLATE 14. ERUPTION CLOUDS OVER MAYON.

PLATE 15. THE CRATER CLOUD OF MAYON.

PLATE 16. MAYON IN ERUPTION, JULY 23, 1928.

PLATE 17. DARK ASH CLOUDS ABOVE MAYON.

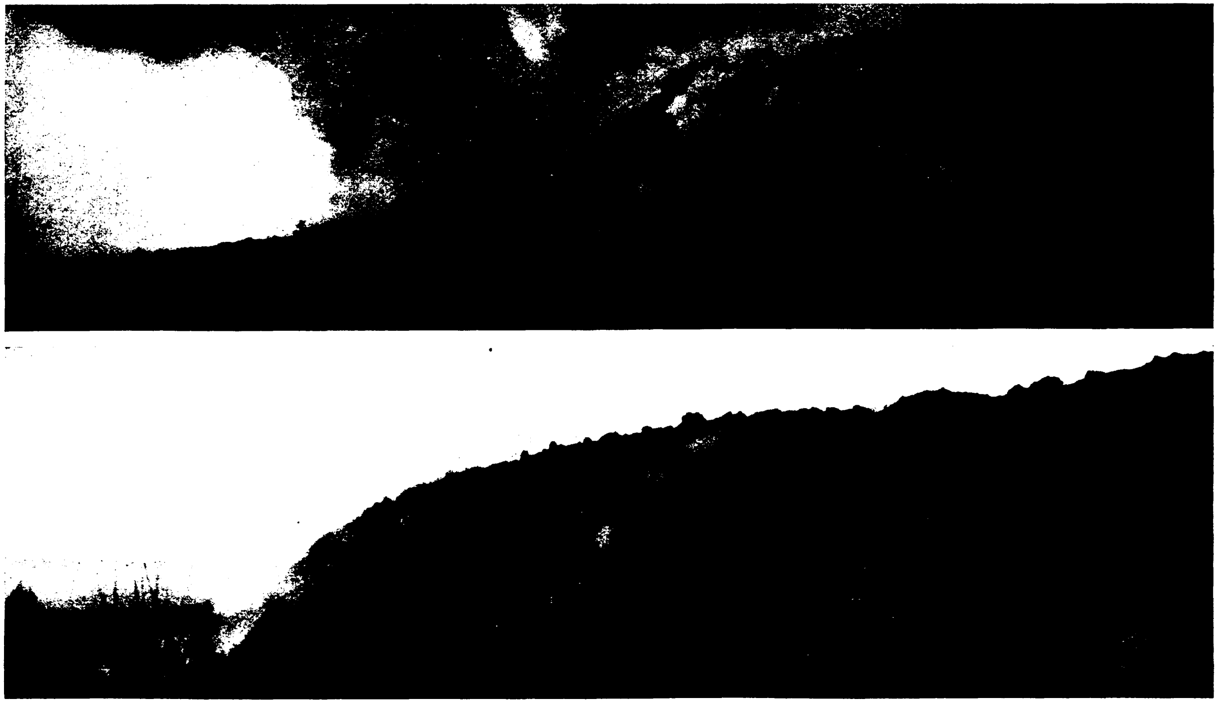

PLATE 18. ADVANCING FRONT OF LAVA ON MOUNT MAYON.

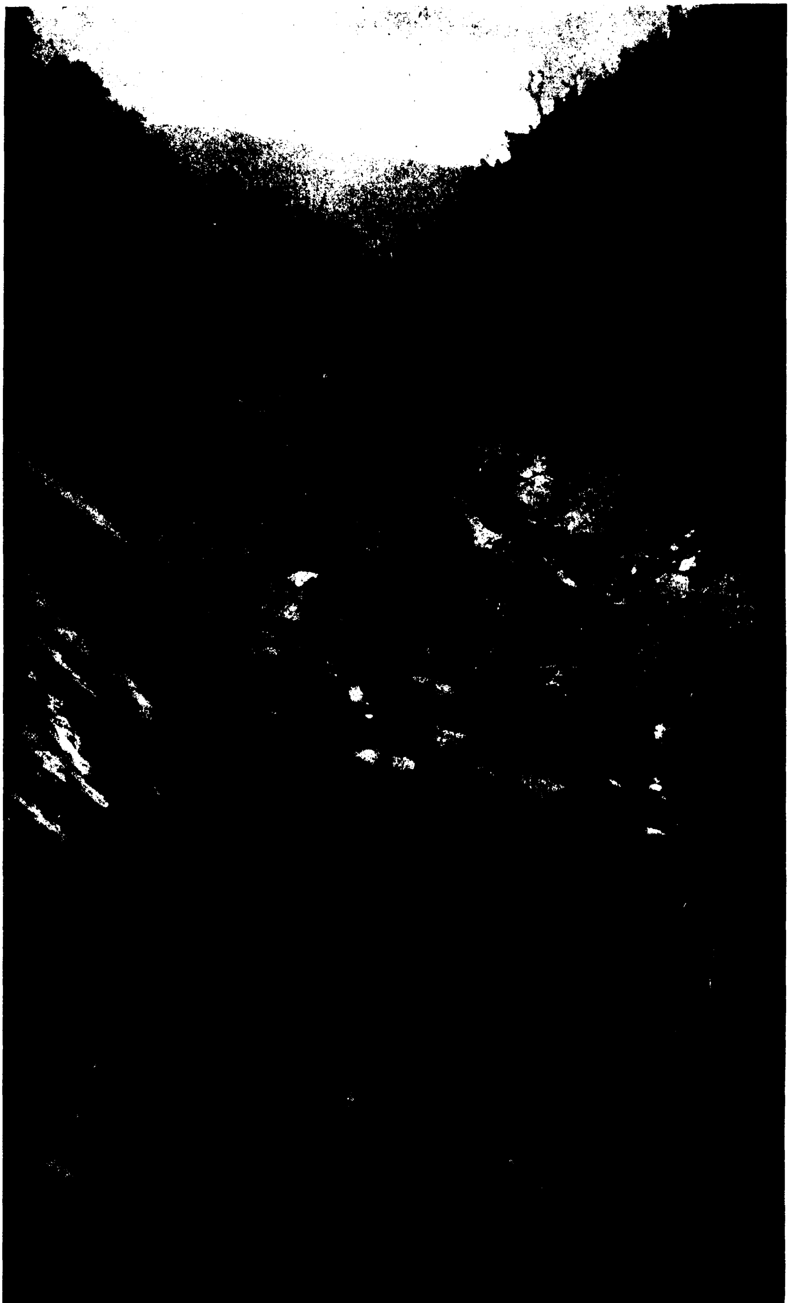

PLATE 19. ONE OF THE RAVINES ON MOUNT MAYON.

PLATE 20. AN ASH CLOUD DIRECTLY OVERHEAD.

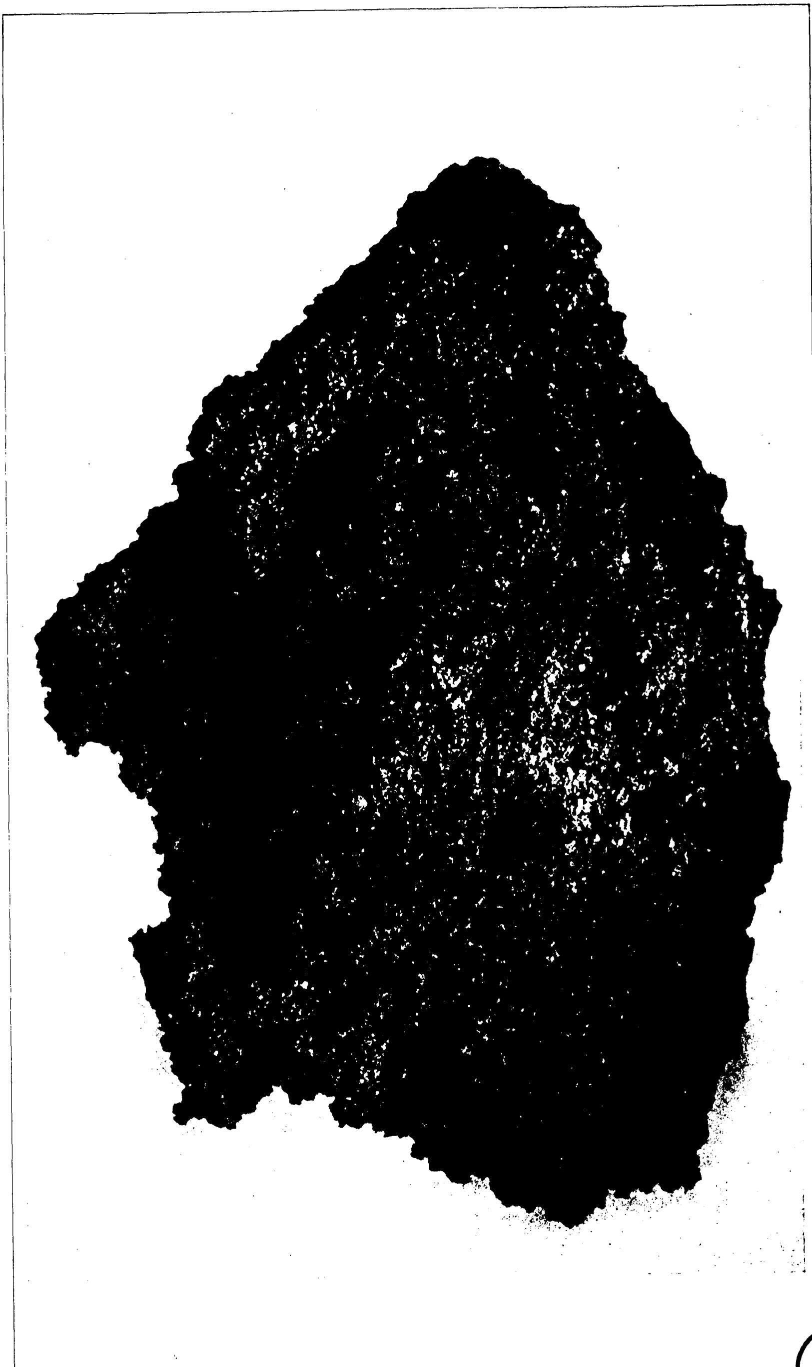

PLATE 21. LAVA FROM THE ADVANCING FRONT, MOUNT MAYON.

NOTE ON THE DURATION OF IMMUNITY TO YAWS IN PHILIPPINE MONKEYS [1]

By B. TANABE [2]

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Sufficient evidence is on hand that resistance to yaws exists in yaws-infected animals [3] and men.[4] The dependence of the development of this resistance upon the time factor has been clearly demonstrated. There are some experiments indicating that once the resistance has developed it lasts for a considerable time. This fact has been substantiated in experiments on human volunteers and on animals. In the Philippines it has been found that the resistance lasts at least two years.

The object of the present investigation was to ascertain, first, whether or not this long duration of resistance is generally true in all cases or is subject to individual variations; and, second, whether or not the resistance to inoculation lasts longer than two years.

A long series of animals in which the yaws had healed was selected for this experiment. These animals were inoculated at various intervals after the original inoculation. The inoculations were well controlled by simultaneous inoculations made on normal control animals to prove that the inoculum contained viable treponemas. The technic of inoculation was the same as described previously from this institution.[5]

Table 1 shows the results of this experiment. The animals are arranged according to the length of time that elapsed between the first successful inoculation with yaws and the test for resistance.

[1] Received for publication, December 14, 1928.

[2] Lieutenant Colonel, Imperial Japanese Army.

[3] Philip. Journ. Sci. **35** (1928) 279.

[4] Philip. Journ. Sci. **22** (1923); **30** (1926) 465.

[5] Philip. Journ. Sci. **35** (1928) 216.

TABLE 1.—*Tests for duration of resistance in yaws-infected Philippine monkeys.*

[All normal control animals developed yaws; D, died; —, no lesion (immune). For the sake of easier calculation the months are indicated by Roman numerals, the days and years by Arabic figures.]

Designation of monkey.	Date of first successful inoculation.	Last test for resistance.		Result of the test for resistance.	Under observation until—
		Date.	Months after the first inoculation.		
			Months.		
W-2	VIII- 6-27	III-27-28	7	—	VIII-16-28 D.
D-14	VII-18-27	III-27-28	8	—	IV-3-28 D.
B-6	IV-12-27	I-24-28	9	—	XI-30-28.
C-6	IV-18-27	I-25-28	9	—	VI-18-28.
Y-4	V-31-27	III-27-28	10	—	XI-30-28.
G-10	IV- 4-27	III-27-28	11	—	IV-13-28 D.
O-d	III-11-27	III-27-28	12	—	XI-30-28.
B-5	I-15-27	I-24-28	12½	—	XI-30-28.
P-13	II- 1-27	III-26-28	13	—	XI-30-28.
K-7	I-15-27	III-26-28	14	—	XI-30-28.
G-9	I-24-27	III-27-28	14	—	IV-3-28 D.
J-15	XI- 5-26	III-26-28	15	—	XI-30-28.
J-16	XI- 5-26	III-26-28	15	—	XI-30-28.
H-20	XI- 8-26	III-26-28	15	—	XI-30-28.
L-6	XI-15-26	III-26-28	15	—	XI-13-28 D.
A-6	I- 6-27	IV-11-28	15½	—	XI-30-28.
A-7	I-11-27	IV-11-28	15½	—	X-23-28 D.
M-4	IX-13-26	III-26-28	17	—	IV-13-28 D.
E-17	XI-26-26	IV-11-28	17	—	XI-30-28.
E-16	X-27-26	IV-11-28	18	—	IV-30-28 D.
T-4	VII- 2-26	III-26-28	20	—	XI-30-28.
T-10	VII-20-26	III-25-28	20	—	X-1-28 D.
O-c	VI-27-26	III-26-28	21	—	XI-30-28.
C-2	III- 8-26	I-25-28	22	—	X-31-28 D.
J-11	III-19-26	III-26-28	24	—	XI-30-28.
L-5	III-24-26	III-26-28	24	—	XI-30-28.
D-8	IV-25-25	II- 4-28	33½	—	XI-30-28.
B-K-3	V-23-25	IV-11-28	34	—	VI-28-28 D.

The following conclusions can be drawn from these experiments:

Without exception the duration of the resistance once developed in healed-yaws animals is long. The period of time that elapsed between the original inoculation with yaws to the final test for resistance in these experiments ranges from seven to thirty-four months. There is every reason to believe that the resistance to yaws in Philippine monkeys persists throughout life.

These experiments complete and amplify the evidence already afforded by the results previously published from this institution,[6] and show that the immunity lasts longer than two years.

The animals that were tested for immunity were kept under observation for the periods indicated in the table. I observed these animals up to May 15, 1928; after my departure from Manila the inspection of the animals was continued by Dr. Otto Schöbl and Dr. I. Miyao, and for their courtesy I here record my thanks.

[6] Philip. Journ. Sci. **35** (1928) 216.

SEROLOGIC STUDIES IN EXPERIMENTAL YAWS [1]

By Otto Schöbl

Chief, Division of Biology and Serum Laboratory
Bureau of Science, Manila

Part of the program in our inquiry into the problem of experimental yaws was the study of serologic changes as they occur in experimental framboesia in Philippine monkeys.

The behavior of the Wassermann reaction in experimental infection and in immunity following the experimental infection has been dealt with in a previous report of our experiments.[2] The conclusions are reproduced here for the convenience of the reader.

14. The Wassermann reaction is indefinite and ephemeral in the case of early local yaws. Its strength and persistence depend upon the duration of infection, the number of yaws lesions, the intensity of the lesions, and, to a lesser extent, on the number of superinoculations.

15. The Wasermann reaction, if it has become negative due to treatment or spontaneous healing and if all the lesions have disappeared, will reappear upon unsuccessful superinfection or reinoculation with viable material.

16. The serologic reactivity of the body organism to superinfection (that is, the reappearance of Wassermann reaction) and the reactivity of the organism to treatment, which manifests itself as a disappearance of the Wassermann reaction becomes sluggish upon repeated reinoculations and treatments.

17. The reappearance of a postive Wassermann reaction can be produced in healed and cured animals without recurrence of yaws lesions and, therefore, a positive Wassermann reaction does not necessarily mean the existence of viable Treponema pertenue in the body organism of the animal.

Since then further experiments have been projected by the senior author and performed in collaboration with guests and staff members of the Bureau of Science with the purpose of elucidating by experimental means certain points concerning the nature of the so-called "reagin" of the Wassermann and

[1] Received for publication, December 14, 1928.

[2] Philip. Journ. Sci. **35** (1928) 261.

allied reactions. Perhaps additional use in practical medicine can be found in the interpretation of coördinated results of these serologic reactions in treponematoses.

The embarrasingly voluminous literature concerning the serology of treponematous diseases is surprisingly wanting in experimental evidence. The Wassermann reaction has been from the beginning a clinical method. Consequently the use of this reaction has been almost exclusively diagnostic or indicative of the efficacy of the treatment. The possibilities of its prognostic value have apparently remained unnoticed. The broader questions dealt with in these experiments were the following:

1. Is the Wassermann reagin, so called, a true antibody as we understand this term in bacterial immunity and is its peculiar nature due to the peculiarity of the microörganism which causes its appearance in the infected body or is it a phenomenon utterly different from those accompanying bacterial immunity?

2. Does the positive Wassermann reaction necessarily and without exception mean the presence in the body organism of living treponemas, or may it persist after these have been killed or have disappeared from the body?

In these experiments answers to the following questions were sought:

1. Is the yaws antigen which produces positive Wassermann reaction when injected into the body thermostable and to what degree?

2. Is there a relation between the number of vaccinations with yaws antigen and the strength of the Wassermann reaction that develops in consequence thereof?

3. Is there a relation between the time of appearance of the Wassermann reaction and the number of vaccinations?

4. What is the effect of infection upon the Wassermann reaction as produced by yaws vaccination?

5. Once a positive Wassermann reaction is produced by vaccination, how long may it last?

6. What is the effect of yaw's revaccination upon the Wassermann reaction as produced by vaccination?

7. Is the Wassermann reaction produced in experimental animals by vaccination a specific reaction?

8. Following subcutaneous injection of yaws vaccine is the skin proper or the lymphatics or the muscle responsible for the appearance of positive Wassermann reaction?

9. What is the relation, with regard to treponema antigen, of the Wassermann reaction to the reactions the underlying principle of which is precipitation of antigen (Kahn test)?

In a previous communication [3] one of us noted an observation which led to the investigations presented in these papers.

When normal Philippine monkeys were injected subcutaneously with yaws material in such a manner that the development of skin lesion was prevented they showed a strong Wassermann reaction. They were kept under observation for a considerable time and failed to develop any clinical sign of yaws aside from positive Wassermann reaction. The conventional explanation of this phenomenon would take it for granted that latent infection was induced by this manner of inoculation. Previous observations of our own on experimental animals [4] and humans,[5] and observations of others on humans,[6] led us to suspect that a positive Wassermann reaction in yaws does not necessarily indicate the presence in the patient's or in the experimental animal's body of viable treponemas. When yaws lesions heal in the early stage, either spontaneously or due to specific treatment, all the clinical manifestations disappear, but the positive Wassermann reaction may persist for months before it disappears, and the patient or the experimental animal may live for years without any relapse whatsoever of clinical yaws, enjoy good health, have the appearance of a healthy robust individual, and give in due time repeatedly negative Wassermann reaction.

In order to demonstrate experimentally whether or not a positive Wassermann reaction necessitates the presence in the body organism of viable treponemas the experiments herewith presented were performed. It may be that a stage of latency has developed in the experimental animals used in the above-quoted experiments which may or may not lead to relapse later on. On the other hand, the possibility exists that the body tissues have been so sensitized by the infection that they continue for some time to produce Wassermann reagin in spite of the fact that stimulation of the tissues by the presence of live treponemas in the body has ceased. One is inclined to decide in favor of the last supposition because it is easily demonstrable

[3] Philip. Journ. Sci. 35 (1928) 295.

[4] Loc. cit.

[5] Schöbl, Otto, and José Ramirez, Philip. Journ. Sci. 30 (1926) 483.

[6] Navarro, R., Philip. Journ. Sci. 30 (1926) 445.

in yaws infection that Wassermann reaction which became negative either spontaneously or due to treatment can readily be made to reappear upon superinfection even though the superinfection takes place in the resistant stage and does not result in a clinical lesion. Consequently, more experiments were arranged to elucidate this point if possible. The results are presented in the following series of papers.

EXPERIMENTS CONCERNING THE YAWS ANTIGEN WHICH PRODUCES POSITIVE WASSERMANN REACTION WHEN INJECTED IN SUITABLE EXPERIMENTAL ANIMALS [1]

By OTTO SCHÖBL and BUNSHIRO TANABE [2]

Of the Division of Biology and Serum Laboratory
Bureau of Science, Manila

ONE TEXT FIGURE

EXPERIMENTAL PROCEDURE

Before we commence the description of individual experiments we wish to make certain general remarks concerning the technic of the Wassermann reaction as used in these experiments, and the interpretation of the results.

The technic was the same as described on previous occasion.[3] That is to say, both alcoholic antigen and cholesterinized antigen were used. Guinea pig pooled complement and antimonkey hæmolytic system were employed. The readings of the inhibition of hæmolysis as given in the tables in this paper refer to cholesterinized antigen and ten times diluted complement. In our rather extensive experience with human yaws we have frequently noticed that the inhibition in case of yaws serum is particularly strongly pronounced with the cholesterinized antigen. This, of course, is true as well of syphilis but it rarely happens, if ever, that syphilitic serum gives complete inhibition with cholesterinized antigen and a complete hæmolysis with the same antigen without cholesterine. This is frequently the case both in human and experimental yaws. These apparent differences in the behavior of the syphilitic and frambœsic serum, however, are not such as to guarantee a reliable serologic differential diagnosis between syphilis and yaws. We have re-

[1] Received for publication, December 14, 1928.

[2] Lieutenant Colonel, Imperial Japanese Army. Colonel Tanabe collaborated in these experiments up to his recall May 15, 1928.

[3] Schöbl, Otto, and Carlos Monserrat, Philip. Journ. Sci. § B 12 (1917) 249.

peatedly noticed in our yaws animals, either infected or vaccinated, that their serum will give strong inhibition with cholesterinized antigen but none at all with alcoholic. If the Wassermann reaction in experimental yaws monkeys continues over the stage resistant to inoculation and particularly when it is reenforced by repeated vaccinations, the positive Wassermann with the alcoholic antigen will make its appearance very frequently. Thus we may conclude that it is a difference of degree rather than of kind. Although no significance can be attributed to this phenomenon from the point of differential diagnosis, there is again an agreement between the serologic findings in man and in experimental yaws in monkeys. The interpretation of our findings must be made with this in mind. Nineteen monkeys were used in these experiments, and the results are arranged in tables so that the desired information may be obtained at a glance.

RESULTS OF EXPERIMENTS

In Table 1 experiments are registered that were made with the view of ascertaining the thermostability of the antigen in question.

Repeated injections of the vaccine were made under the skin of the abdomen and the chest at intervals of about a week. The skin was disinfected with alcoholic bichloride solution before and after the insertion of the needle.

As recorded in Table 1 some of the series of monkeys used in this experiment received unheated vaccine, others received vaccine heated for one hour at 60° C., others at 80° C., and still others at 100° C. Approximately one month after the first vaccination the blood was withdrawn from the heart of the animal and subjected to Wassermann test. It can be seen from the results tabulated herewith that the antigen producing positive Wassermann in yaws when injected into experimental animals does so irrespective of whether the material is alive or heated. In other words, its thermostability is considerable. These results dispose of the supposition that would take latent infection as an explanation for the occurrence of positive Wassermann reaction in animals repeatedly injected with unheated yaws vaccine without production of yaws lesions. The viability of our strain of Treponema framboesiæ has been studied in this laboratory by Yasuyama [4] and it was experimentally demonstrated

[4] Philip. Journ. Sci. **35** (1928) 333.

TABLE 1.—*Is the treponema antigen thermostable and to what degree?*

[—, no inhibition; ±, less than 25 per cent inhibition; +, 25 per cent inhibition; ++, 50 per cent inhibition; +++, 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done.]

Designation of monkey.	Number of vaccinations and the dates of first and last vaccination.				Vaccine.		Wassermann reaction before vaccination.	Date and result of Wasserman reaction after vaccination.
					Not heated.	Killed.		
N-12	1. II- 3-27	2	3	4. III- 9-27	+		0	V-12-27 ++++
D-12	1. II- 3-27	2	3	4. III- 9-27	+		0	V-12-27 +++
W-22	1. I-19-28	2	3. II- 8-28		—	+ 60° C. 1 hr.	—	I-31-28 +++
W-23	1. I-19-28	2	3. II- 8-28		—	+ 60° C. 1 hr.	—	I-31-28 ±
W-57	1. III- 5-28	2	3. III-20-28		—	+ 80° C. 1 hr.	—	IV-7-28 +++
W-58	1. III- 5-28	2	3. III-20-28		—	+ 80° C. 1 hr.	—	IV-7-28 ++++
A-8	1. IV-11-28	2	3. IV-27-28		—	+ 100° C. 1 hr.	±	V-17-28 +
K-9	1. IV-11-28	2	3. IV-27-28		—	+ 100° C. 1 hr.	±	V-17-28 +

that Treponema framboesiæ does not live long outside of the body. Control animals in our experiments when inoculated intradermally with the vaccine persistently failed to develop yaws. There is no doubt, therefore, that the treponemas contained in the vaccine as used in these experiments were dead. Consequently a positive Wassermann reaction can be induced in suitable experimental animals with dead treponemas, and actual infection is not the only cause of a positive Wassermann reaction.

TABLE 2.—*The relation between the number of injections of yaws vaccine and the strength of the Wassermann reaction.*

Designation of monkey.	Number of weekly vaccinations.	Vaccine.		Wassermann reaction before vaccination.	Result of Wassermann reaction after vaccination.
		Unheated.	Killed.		
N-12	4	+		0	++++
D-12	4	+		0	+++
W-22	3		+ 60° C. 1 hr.	—	+++
W-23	3		+ 60° C. 1 hr.	—	±
W-57	3		+ 80° C. 1 hr.	—	+++
W-58	3		+ 80° C. 1 hr.	—	++++
W-26	2		+ 60° C. 1 hr.	—	++
W-27	2		+ 60° C. 1 hr.	—	+
W-25	2		+ 60° C. 1 hr.	—	±
W-59	2		+ 80° C. 1 hr.	—	++
W-60	2		+ 80° C. 1 hr.	±	+
E-40	1		+ 60° C. 1 hr.	—	—
E-41	1		+ 60° C. 1 hr.	—	—
W-39	1	+		—	—
W-61	1		+ 80° C. 1 hr.	—	—
W-62	1		+ 80° C. 1 hr.	—	—

The relation between the number of injections of yaws vaccine and the strength of the Wassermann reaction was investigated on a series of experimental animals (Table 2) that received decreasing numbers of vaccinations in the manner just described. Two monkeys received four injections of unheated vaccine; four monkeys received three injections of heated vaccine; five monkeys received two injections of heated vaccine; one monkey received one injection of unheated vaccine and four monkeys received one injection of heated yaws vaccine.

We can see at a glance that the strongest Wasserman reactions occurred in the monkeys that received the largest numbers of vaccinations, while those monkeys that received only one vaccination were negative at that time. The monkeys that were

vaccinated four times showed an average of 3.50 pluses. The ones that received three vaccinations showed an average of 2.625. Those that received two injections showed an average of 1.30 pluses. There is a steady decrease of the strength of the Wassermann reaction following the decrease in the number of vaccinations. There are, however, individual variations. This may be due to the quantity factor or to the time factor. In other words those animals that received a lesser number of injections may develop positive Wassermann reaction later than those that received more vaccinations. This question will be treated together with the duration of the positive Wassermann reaction as produced by vaccination.

TABLE 3.—*What is the effect of infection upon Wassermann reaction as produced by yaws vaccination?*

Designation of monkey.	Number of vaccinations.	Vaccine.		Wassermann reaction before vaccination.	Wassermann reaction after vaccination.	
		Unheated.	Killed 1 hour at—		Before infection.	After infection.
H-12	4	+		0	++++	++++
D-12	4	+		0	+++	++++
W-22	3		+ 60° C. 1 hr.	—	+++	++++
W-23	3		+ 60° C. 1 hr.	—	±	+++
W-26	2		+ 60° C. 1 hr.	—	++	++++
W-27	2		+ 60° C. 1 hr.	—	+	++++
W-25	2		+ 60° C. 1 hr.	—	±	++++
E-40	1		+ 60° C. 1 hr.	—	—	—
E-41	1		+ 60° C. 1 hr.	—	—	+
E-39	1	+		—	—	±
Average of pluses					1.55	3.18

The effect of infection with viable treponemas upon the Wassermann reaction as produced by yaws vaccination is evident from Table 3. Three groups of vaccinated animals were selected for this purpose; one group of two animals with strong Wassermann reaction, another group of five animals with moderately strong, and one group of three animals with negative Wassermann. The Wassermann test was performed before the infection with live material took place. It was then repeated approximately one month after the infection. There is a constant increase of the strength of the Wassermann reaction in the vaccinated animals after the infection. The last three animals that before vaccination showed negative Wassermann make an

exception. They received only one vaccination and were reexamined about a month after the infection. There was a slight increase of Wassermann in two cases out of three at the time the animals were examined. This last group behaves with respect to Wassermann reaction in the same manner as do normal monkeys infected for the first time.[5]

The persistence of the Wassermann reaction after vaccination was investigated in a group of five animals (Table 4). Two of them received three vaccinations and showed a strong Wassermann reaction about one month after vaccination; two of them received two vaccinations and showed moderately positive Wassermann reaction; and one of them received one vaccination and showed negative Wassermann reaction. In this experiment not only the duration was investigated but also the question whether or not the time factor enters into the appearance of a positive Wassermann reaction. That is to say, whether or not the animals that received only one injection develop a positive Wassermann reaction later than those that received more than one injection.

In addition to these five animals, two monkeys were injected with diluted vaccine three times at weekly intervals. This was done to bring out the quantitative relation of the amount of the vaccine, and the strength of the serum reaction and the time at which the positive Wassermann reaction becomes detectable by the method employed in our investigation. The result of this experiment is presented in Table 4.

The two animals that received three vaccinations at weekly intervals and gave negative result prior to vaccination showed strong Wassermann reaction when examined about one month after the first vaccination, a moderately positive Wassermann reaction two months after the first vaccination, and a negative result when reëxamined two months and three weeks after the first vaccination.

The two monkeys that received two vaccinations and were negative or gave a plus-minus Wassermann reaction prior to the vaccination showed weak and moderate Wassermann reaction respectively one month after the first vaccination, a doubtful and weak Wassermann reaction two months after, and doubtful reaction two months and three weeks after the first vaccination.

[5] Philip. Journ. Sci. 35 (1928) 261–272.

TABLE 4.—*Following vaccination how long may the Wassermann reaction last?*

Designation of monkey.	Vaccinations.						Vaccine heated for 1 hour at—	Wassermann reaction before vaccination.	Date and result of Wassermann reaction after vaccination.	
	Number.	Date.	Number.	Date.	Number.	Date.				
W-57	1	III-5-28	2	III-12-28	3	III-20-28	+ 80° C	—	IV- 7-28 V- 3-28 V-28-28	+++ ++ —
W-58	1	III-5-28	2	III-12-28	3	III-20-28	+ 80° C	—	IV- 7-28 V- 3-28 V-28-28	+++ + —
W-59	1	III-5-28	2	III-12-28			+ 80° C	—	IV- 7-28 V- 3-28 V-28-28	++ + ±
W-60	1	III-5-28	2	III-12-28			+ 80° C	±	IV- 7-28 V- 3-28 V-28-28	+ ± ±
W-61	1	III-5-28					+ 80° C	—	IV- 4-28 V- 3-28 V-28-28	— + +
W-63	1	III-5-28	2	III-14-28	3	III-20-28	+ 60° C [a]	—	IV- 7-28 V- 3-28 V-28-28	— ± —
W-64	1	III-5-28	2		3	III-20-28	+ 60° C.[a]	±	IV- 7-28 V- 3-28 V-28-28	± + —

TABLE 5.—*What is the effect of revaccination upon Wassermann reaction produced by yaws vaccination?*

Designation of monkey.	Number of vaccinations.			Vaccine killed 1 hour.	Wassermann reaction before vaccination.	Wasserman reaction after vaccination.		
						Before revaccination.	After 1st revaccination V-31-28.	After 2nd revaccination VII-17-28.
						+++ IV- 7-28	± VI-21-28	— VII-30-28
W-57	1	2	3	80° C.	—	++ V- 3-28	— VII- 5-28	0
						— V-28-28	— VII-17-28	0
						++ IV- 7-28	± VI-21-28	— VII-30-28
W-59	1	2	3	80° C.	—	+ V- 7-28	— VII- 5-28	0
						± V-22-28	— VII-17-28	0
						— IV- 7-28	++++ VI-20-28 VI-21-28	— VII-30-28
W-61	1	----	----	80° C.	—	+ V- 7-28	— VII- 5-28	0
						+ V-28-28	— VII-17-28	0

The three monkeys one of which received only one vaccination and the other two that were given three vaccinations with highly diluted vaccine showed no difference between the results of the tests performed prior to and one month after the vaccination but showed slight increase of inhibition two months and three weeks after the vaccination.

The effect of revaccination upon the Wassermann reaction in three yaws-vaccinated monkeys was studied in the following experiment (Table 5).

One of the three monkeys received three vaccinations and gave strong Wassermann reaction. Another monkey received three vaccinations and gave moderately positive result. The third one having received only one vaccination gave a weak and delayed Wassermann reaction. All of the three animals gave negative result prior to vaccination. The strength of the Wassermann reaction having been established in these animals as a result of vaccination, the time was awaited when the reaction had become negative in one animal, doubtful in another, and weak in the third. At this time the monkeys received one injection of yaws vaccine. The response to the new incorpora-

tion of yaws vaccine was very weak in the first two monkeys, which having received three vaccinations gave strong and moderate results, respectively. In the third animal which received only one vaccination and consequently showed weak and delayed Wassermann reaction the response to revaccination was very strongly pronounced; that is, a strong Wassermann reaction resulted. A second revaccination was performed when all of the three monkeys had reached serologic normalcy and gave negative results on two successive tests. The response to the second revaccination on the part of each of the three monkeys was nil.

DISCUSSION

In monkeys infected with yaws and treated the following findings were made:[6]

> When the process of alternating infection and treatment was continued for a long period of time, the promptness of disappearance of the Wassermann reaction after treatment and its reappearance after reinoculation was considerably decreased, and a stage was reached at times in which a low-grade Wassermann reaction persisted practically unchanged by either of the two procedures mentioned.

In yaws-vaccinated monkeys the same phenomenon of exhaustion on the part of the body organism of serologic reactivity to the incorporation of antigen can be discerned. The exhaustion of serologic reactivity sets in much earlier after vaccination than in actual yaws infection, because the impetus as well as the serologic response is more sudden in vaccination than in actual infection.

This statement is illustrated in fig. 1. The curves were drawn merely to show their shape and type. The intervening details may be found in the respective tables. The first seven curves represent the behavior of the Wassermann reaction during the process of repeated infections and cures interposed between the infections. They were compiled from a table previously published.[7] The last three curves illustrate the behavior of the Wassermann reaction following vaccination with killed Treponema framboesiæ without intervening treatment and were compiled from Table 5 attached to this paper.[8] Curve 1 referring to monkey B–3 of previous publication we consider as prototype. It shows a rise in the titre of the Wassermann reaction follow-

[6] Philip. Journ. Sci. 35 (1928) 333.
[7] Philip. Journ. Sci. 35 (1928) 274, Table 9.
[8] Philip. Journ. Sci. 40 (1929) 1.

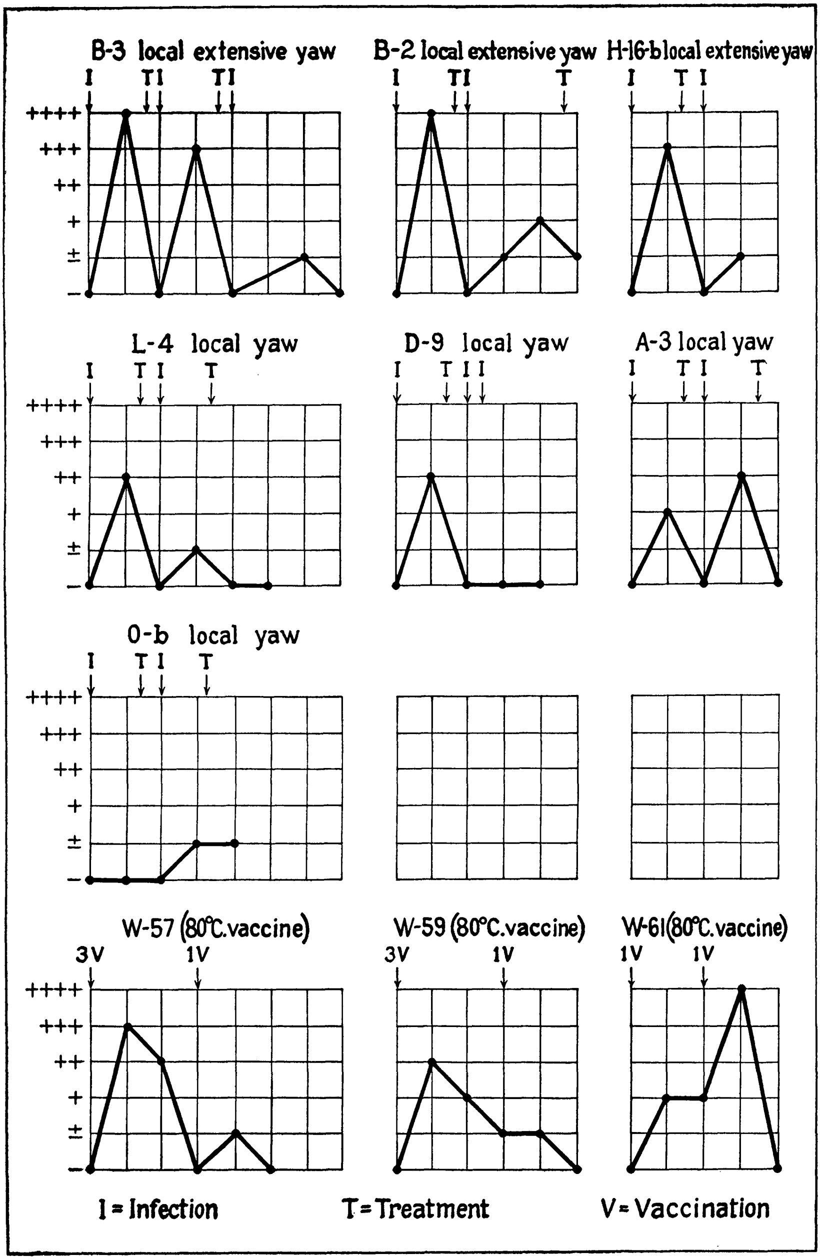

FIG. 1. Results of Wassermann reaction in repeatedly infected and cured monkeys compared with results obtained in repeatedly vaccinated monkeys.

ing infection with yaws. Then follows a drop caused by the treatment. When the Wassermann reaction disappeared another infection was performed in consequence of which the titre of the Wassermann reaction rose again only to drop to negative following a treatment. The third infection, performed when the Wassermann reaction had become negative, again caused a rise in the titre of the Wassermann reaction. In this typical case each following rise of the curve is less than the previous one, but on treatments the curve returned to zero. The second curve compiled from the record of monkey B–2 is a slight modification of the first one, the general course of the curve as far as it has been followed being the same. So is curve 3 (monkey H–16–B) and curve 4 (monkey L–4) but curve 5 (monkey D–9) shows only the initial rise. After the first infection it rose, then, following the treatment it dropped to zero and continued at zero. In other words the second rise following infection is absent. Nevertheless the curve follows the type of the previous ones.

The second type of curve obtained in this experimental investigation is evident from curves 6 and 7. The original infection produced a rise in Wassermann reaction and a drop to zero following the treatment (in animal A–3). The second infection performed at the time of serologic cure lifted the curve to a higher point than the first infection in the same monkey (A–3). Curve 7 is of the same general type as the previous one but the first rise is absent.

It is interesting, in view of our explanations of the behavior of the Wassermann reaction following infection with yaws and its relation to the severity of infection, to note that curves 1, 2, and 3 were observed in monkeys showing an extensive local lesion.

The last three curves (monkeys W–57, W–59, and W–61) are drawn from the results of Wassermann reactions performed on monkeys vaccinated with treponemas killed by heating at 80° C. for one hour. The first two (monkeys W–57 and W–59) received three vaccinations previous to the first test, and the response was strong as expressed by the degree of the positive Wassermann reaction. Revaccination given on the decline of the curve brought a far lesser serologic response than the first vaccination. These two curves (monkeys W–57 and W–59) follow the same type as the first curve in a repeatedly infected and

cured yaws monkey (B–3). It is significant that both these animals have received three vaccinations previous to the first test. In the last curve monkey W–61 received only one vaccination, and the response to that first vaccination was mild (+). Upon revaccination the curve rose to a higher point after which it dropped to zero. The last-mentioned curve (monkey W–61) is of the second type noticed in repeatedly infected and treated monkeys, that is the type of curve noticed in monkey A–3. From this illustration it is more clearly evident, than from the discussion, that the vaccination with killed Treponema framboesiæ produces results identical with those observed in repeatedly infected and treated monkeys. Likewise vigorous vaccination produces the same type of curve as vigorous infection while injection of a small amount of killed yaws vaccine produces the type of curve noticed in animals slightly reactive to infection.

SUMMARY AND CONCLUSIONS

1. Repeated subcutaneous injections of killed Treponema framboesiæ produce in Philippine monkeys a positive Wassermann reaction.

2. The strength of the Wassermann reaction is in direct proportion to the number of subcutaneous injections of killed treponemas.

3. The length of the pre-Wassermann stage in monkeys immunized with killed treponemas is in inverse proportion to the number of injections.

4. The positive Wasserman reaction in experimental monkeys, having reached its full strength as a consequence of repeated subcutaneous injections of killed treponemas, declines rather rapidly and in due time becomes negative.

5. The response of the body to the introduction of the lifeless antigen, which response manifests itself as a recrudescence of Wassermann reaction following revaccination administered after a period of negative reactions, becomes more and more sluggish with each subsequent revaccination.

6. The strength of the Wassermann reaction that follows the revaccination stands in inverse proportion to the strength of the reaction following the preceding vaccination, and, consequently, it is in inverse proportion to the amount of vaccination.

7. Individual variations in the serologic response exist in the animals used in our experiments.

ILLUSTRATION

TEXT FIG. 1. Chart showing results of Wassermann reaction in repeatedly infected and cured monkeys compared with results obtained in repeatedly vaccinated monkeys.

IS THE WASSERMANN REACTION PROVOKED IN PHILIPPINE MONKEYS BY YAWS VACCINATION SPECIFIC? [1]

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INTRODUCTION

It was demonstrated by Schöbl and Tanabe [3] that monkeys inoculated with killed yaws vaccine will show positive Wassermann reaction a certain time after the vaccination. The fact that the vaccinated animal's blood shows negative Wassermann reaction prior to, and positive reaction sometime after the vaccination may be taken as sufficient proof that this phenomenon is a specific Wassermann reaction. The quantitative relation between the strength of the reaction and the amount of vaccine or number of vaccinations leaves no doubt that the phenomenon under discussion is due to the vaccination.

However, the possibility of error must be considered, and it must be demonstrated that the treponemas originally present in the vaccine contain the substances which act in vivo as an antigen of the Wassermann reagin. Led by the idea of incriminating the treponemas in the vaccine as the responsible factor for the appearance of positive Wassermann reaction in vaccinated monkeys I have endeavored to eliminate the possibility of factors other than the treponemas.

In the experiment presented in this paper I have endeavored to eliminate the blood serum, the lymph, the normal and pathologic inflammatory cellular elements contained in the vaccine as well as the microörganisms that may be present in a superficial skin lesion, such as a yaws lesion. The procedure was as follows: The vaccine was filtered as soon as prepared. The filtrate obtained in such a way was used for subcutaneous injection into monkeys to ascertain whether or not the antigen is free in the

[1] Received for publication, December 14, 1928.

[2] Lieutenant Surgeon, Imperial Japanese Navy.

[3] Antea 57.

liquids of the lesion. The vaccines that were employed in this filtration experiment were tested separately for their antigenic potency. Furthermore, I attempted to eliminate the elements contained in the vaccine; that is, skin tissue and inflammatory cellular elements.

Although it was not likely that the skin and the inflammatory cellular elements would be responsible for the appearance of a positive Wassermann reaction it was not altogether impossible that tissues of yaws monkeys might have been changed to such a degree as to participate in the production of the reagin. Consequently, five experiments were carried out.

First, monkeys were injected repeatedly under the skin with the filtrate of fresh live yaws vaccine. Following this vaccination the blood was repeatedly tested for Wassermann reaction at the intervals of time given in the tables.

Second, normal skin of normal monkeys was scraped off, ground up, suspended in normal salt solution, and heated at 80° C. for one hour. Repeated injections of this emulsion were given after which the animal's blood was tested for Wassermann reaction.

Third, normal skin tissue of monkeys infected with yaws was used for the preparation of vaccine, as just described, and normal monkeys received repeated injections of this vaccine.

Fourth and fifth, in order to convince myself that nonspecific inflammatory tissue is not responsible for the production in vivo of the reagin, normal monkeys as well as yaws monkeys were vaccinated with smallpox vaccine on the normal part of the skin. When the take fully developed it was scraped off, ground up and heated, and used for repeated subcutaneous injections into normal monkeys. Following the vaccination with these various emulsions the animals showed negative Wassermann reactions on repeated examination. They were then infected with yaws and after the infection and superinfection their blood was again examined by Wassermann reaction to prove that those animals were capable of producing positive Wassermann.

From the tabulated results it can be seen that the filtrate of a potent yaws vaccine raised very slightly the Wassermann reaction. This shows that the antigen which produces positive Wassermann reaction when repeatedly injected under the skin of monkeys was to a great extent caught by the filter and only a very small part of it passed through. The filtrate of the yaws vaccine acted like the highly diluted vaccine.

TABLE 1.—*Showing the serologic results of subcutaneous injections of yaws vaccine from which treponemas have been removed by filtration through Berkefeld filter.*

Description of monkey.	Number of vaccinations.	Wassermann reaction.	
		Before vaccination.	After vaccination.
W-63-a	3	—	±
W-63-b	3	±	+

Experiments 2, 3, 4, and 5 are tabulated in Table 2. They show that repeated injections of normal skin as well as nonspecific exudative skin lesion from either normal or yaws monkeys failed to produce serologic changes in animals of the same species. The presence, therefore, in the vaccine of the treponemas is necessary for the production of positive serologic reactions. In other words the Wassermann reaction produced by yaws vaccine is specific.

CONCLUSIONS

These experiments show that repeated injections of normal skin tissue or inflammatory skin tissue from normal or yaws-infected monkeys failed to produce positive Wassermann reaction.

Repeated injections of potent yaws vaccine from which the treponemas have been removed by filtration produced no appreciable serologic change in monkeys.

These findings are sufficient proof that the presence in the vaccine of treponemas is necessary for the production of positive Wassermann reaction, and that this serum reaction produced by yaws vaccine is specific in the sense that it is an antibody produced by the antigen contained in the treponemas and not a mere consequence of an interaction between viable treponemas and body tissues.

TABLE 2.—*Showing the result of Wassermann reaction in monkeys immunized with normal and inflammatory tissues from normal skin of normal and yaws monkeys.*

[—, negative; ±, less than 25 per cent hæmolysis; +, 25 per cent hæmolysis; ++, 50 per cent hæmolysis; +++, 75 per cent hæmolysis; 0, not done; D, died.]

Designation of monkey.	Kind of tissue used for subcutaneous immunization.	Date and result of Wassermann reaction after immunization with normal and inflammatory tissues.		Date and result of infection with yaws.	Date and result of Wassermann reaction after infection and superinfection with yaws treponemas.						
R-3	Normal skin from normal monkeys.	VI-20-28 —	VII- 5-28 —	VII-19-28 D	IX-3-28 —	IX-13-28 —	IX-27-28 —	X-9-28 D			
R-4	do	VI-20-28 —	VII- 5-28 —	VII-19-28 IX-17-28 yaw	IX-3-28 —	IX-13-28 —	IX-27-28 —	X-9-28 —	X-23-28 +		
S-4	Normal skin tissue from yaws monkey.	VI-20-28 —	VII- 5-28 —	VIII- 2-28 Inoculated yaw	IX-3-28 —	IX-13-28 —	IX-27-28 —	X-9-28 —	X-23-28 ±		
a-1	Inflammatory skin tissues from normal monkey.	VII- 2-28 —	VII-16-28 —	VII-31-28 Inoculated yaw	IX-3-28 —	IX-13-28 ++					
a-2	do	VII- 2-28 —	VII-16-28 —	VII-31-28 Inoculated yaw	IX-3-28 —	IX-13-28 +++					
Z-1	Inflammatory skin tissues from yaws monkey.	VI-20-28 —	VII- 5-28 —	VIII- 2-28 Inoculated yaw	IX-3-28 —	IX-13-28 —	IX-27-28 —	X-9-28 —	X-23-28 —	X-30-28 —	XI-14-28 ±
Z-2	do	VI-20-28 —	VII- 5-28 —	VIII- 2-28 Inoculated yaw	IX-3-28 —	IX-13-28 —	IX-27-28 —	X-9-28 —	X-23-28 —	X-30-28 —	XI-14-28 ±

FOLLOWING THE SUBCUTANEOUS IMMUNIZATION WITH YAWS VACCINE IS THE SKIN TISSUE PROPER RESPONSIBLE FOR THE PRODUCTION OF WASSERMANN REAGIN OR DO OTHER TISSUES ALSO PARTICIPATE? [1]

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The object of this experiment was to find out whether the skin is the principal organ in which the Wassermann reagin in yaws is elaborated or whether other tissues also help in the production of this antibody. The object of this experiment was not to investigate each organ in the experimental animal's body with regard to the question under discussion but mainly to determine into what organ lifeless treponema antigen must be injected to obtain the best results. Consequently the ways of inoculations that are most customary in experimental investigation were applied; that is to say, the subcutaneous, the intraperitoneal, and the intramuscular injection of killed Treponema framboseiæ were given. It has been found that by subcutaneous inoculation of unheated or heated treponemas a positive Wassermann reaction can be produced.[3] It was the question to decide whether the cutis and the subcutaneous tissue, the muscles, or the lymphatic glands, with which the antigen must come in contact following the subcutaneous injection, are responsible for the serologic changes in the blood of the immunized animal. It was to be expected that the skin predominately is involved in the production of Wassermann reagin. This conclusion could be drawn from clinical observation and from experience with Wassermann reaction on yaws-infected monkeys. It is generally known that yaws patients with extensive early skin

[1] Received for publication, December 14, 1928.

[2] Lieutenant Surgeon, Imperial Japanese Navy.

[3] Antea 57.

manifestations give the strongest Wassermann reaction. This is also true in syphilis. In experiments with infected monkeys [4] it was found that the strength of the Wassermann reaction stands in direct proportion to the amount of skin involved by the yaws lesions. Nevertheless, a direct experimental demonstration was lacking. Furthermore, the question whether the skin or the lymphatic tissues are responsible for the appearance of the positive Wassermann reaction could not be deduced from clinical observations or previous experimental findings. It was therefore decided to undertake the experiment presented herewith.

A series of six monkeys was vaccinated with the same lot of yaws vaccine in three different ways; that is, two animals received three injections intraperitoneally, two animals received three injections intramuscularly, and two animals received two injections subcutaneously. This arrangement of vaccination was made with the purpose of demonstrating that the skin is the producer of the Wassermann reagin and not an endothelial lining like the peritoneum, the muscle tissue, or the regional lymph glands. For this reason only two subcutaneous vaccinations were given, while one more was given intraperitoneally and intramuscularly so as to eliminate the possibility of error due to higher dilution of the inoculation antigen in the peritoneum and in the muscles than that injected under the skin. These vaccinations were given at intervals of approximately one week, and about four weeks after the first vaccination the repeated tests of the blood began. All of the animals gave negative result when tested by the Wassermann reaction before and immediately after the vaccination. The animals having been examined at intervals of about two weeks it became apparent that only the two that received two injections of the yaws vaccine under the skin showed positive result, while the animals vaccinated by intraperitoneal and intramuscular injection showed no change whatsoever in their serologic behavior. In order to assure the correctness of these findings revaccination was performed slightly less than two months after the first vaccination. As a result of the revaccination there was a rise from weak to frank positive reaction in one, and from negative to weakly positive in another case of the subcutaneously vaccinated monkeys. After this the reaction declined to negative. The serologic picture in the animals that received intraperitoneal

[4] Philip. Journ. Sci. 35 (1928) 261.

TABLE 1.—*Showing the serologic results after subcutaneous, in traperitoneal, and intramuscular vaccination against yaws.*

[+, 25 per cent inhibition of hæmolysis; ±, less than 25 per cent inhibition of hæmolysis; —, complete hæmolysis; 0, not done.]

Designation of monkey.	Date and modus of vaccination.			Wassermann reaction. Results and dates.				Revaccination, VIII-4-28.	Wasserman reaction after revaccination.	
	First, VI-14-28.	Second, VI-22-28.	Third, VI-30-20.	Before vaccination, VI-30-28.	After vaccination.				VIII-16-28.	VIII-30-28.
					VIII-13-28.	VIII-27-28.	VIII-2-28.			
c-1	Intrap	Intrap	Intrap	—	—	—	—	Intrap	—	—
c-2	do	do	do	—	—	—	—	do	—	—
d-1	Intram	Intram	Intram	—	—	—	—	Intram	—	—
d-2	do	do	do	—	—	—	—	do	—	—
d-3	0	Subcut	Subcut	—	—	±	+	Subcut	±	+
d-4	0	do	do	—	—	±	—	do	±	—

and intramuscular vaccinations remained unchanged by the revaccination.

The result of this experiment appears to be quite instructive, showing that of the three organs tested the skin alone reacted by positive serologic reaction when it came in contact with the lifeless treponema antigen. Although the peritoneum and the muscles received more of the antigen than the skin they failed to respond. This entitles us to the conclusion that the skin tissue proper and not the lymphatic system nor the muscles is responsible for the production of the Wassermann reagin. The antigen reaches the mesenteric lymph glands from the peritoneum just as easy as it reaches the regional glands from the subcutis. Consequently if the lymph glands were the tissues that produce the Wassermann reagin the animals vaccinated by intraperitoneal injection would have given positive Wassermann reaction. This naturally does not prove that other organs, which were not considered in this experiment, are not concerned in the production of Wassermann reagin; but of the tissues that, after the subcutaneous vaccination with treponemas, come first into direct contact with the antigen the skin tissue proper is the one of greatest importance.

THE RELATION OF THE WASSERMANN AND THE KAHN REACTIONS WITH REGARD TO TREPONEMA ANTIGEN [1]

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As a complementary test to the Wassermann reaction the precipitation reactions have justified their use. In a large percentage of comparative tests performed by the two types of methods an agreement was found between the reactions mentioned. The disagreement between these reactions, that is to say, between the Wassermann reaction and the precipitation reactions, was encountered mostly in the early and in the late stage of treponematous diseases. It has been demonstrated that the precipitation reactions are found positive not only in syphilis but also in yaws.

During the experimental study of yaws in Philippine monkeys it has been shown that not only infection but also vaccination with killed treponemas produces positive Wassermann reaction.[2] It was thought opportune, during the study of experimental yaws in monkeys, to study the precipitation reactions, because little or no experimental work on these reactions has been done in the past. Furthermore, it was thought advisable to confirm by the precipitation reactions the serologic findings made by Wassermann reaction in yaws-infected or vaccinated monkeys. Of the several precipitation reactions in practice in the various parts of the world the Kahn reaction is the best known and most popular in America and it was therefore used in these experiments. Having infected and vaccinated monkeys at our disposal we have studied the Kahn reaction itself as it occurs in experimental animals and have compared the results obtained by this reaction with the results obtained by the Wassermann reaction.

[1] Received for publication, December 14, 1928.

[2] Schöbl, O., and B. Tanabe, antea 57; I. Miyao, antea 71 and 75.

TECHNIC

The technic followed in performing the precipitation test was the standard method of Kahn.[3] The serum of the experimental animals when separated, was centrifuged until it was perfectly clear; then it was inactivated at 56° C. for thirty minutes. The serums employed were not more than 24 hours old. Of the inactivated serum 0.15 cubic centimeter was added to each of the three test tubes containing, respectively, 0.05, 0.025, and 0.0125 cubic centimeter of the diluted antigen. The antigen was diluted in salt solution (0.85 per cent) in the proportion of 1.0 cubic centimeter Kahn antigen and 1.1 cubic centimeters of salt solution. The diluted antigen was allowed to stand at room temperature for fifteen minutes before the necessary amount of antigen was delivered into the test tubes. The tubes were placed in a rack and shaken by placing the rack on a table and pushing it to and fro with the hands. The shaking was continued for four minutes. After this 0.5 cubic centimeter of salt solution was added to each of the tubes containing 0.025 and 0.0125, respectively, and 1 cubic centimeter of salt solution was placed into the tube containing 0.05 cubic centimeter antigen. Reading was made immediately after shaking and another after two hours incubation at 37° C. The results of these two readings did not vary essentially, although the degree of precipitation and suspension of the precipitates were easier to read after two hours incubation than immediately after the addition of the salt solution.

Positive and negative serums as well as salt-solution controls were included in every Wassermann and Kahn test.

INTERPRETATION OF THE RESULTS OF THE KAHN TEST

The reading of the precipitates and the recording of plusses as resulted from the reading of the three test tubes were averaged according to the table given in Kahn's book. It deviates from the standard reading in cases in which precipitate was present in the third tube only (0.0125 cubic centimeter). Therefore the one plus; plus minus; one plus lens and plus minus lens can be interpreted as follows:

One plus; Fine precipitate easily detectable with the naked eye.

Plus minus: Very fine precipitate still detectable with the naked eye when carefully examined.

[3] Kahn, R. L., Serum Diagnosis of Syphilis by Precipitation; Governing Principles, Procedure and Clinical Application of the Kahn Precipitation Test. Williams and Wilkins Co.

One plus lens: Fine precipitate easily visible with the aid of a magnifying lens.
Plus minus lens: Precipitate still detectable when examined carefully with the lens but the precipiate is very fine.
Note: Negative-serum and salt-solution controls were always compared before a final reading was made.

With the knowledge gained by the experiments on the viability of Treponema framboesiæ,[4] an experiment was conducted to study the serologic changes produced in monkeys by vaccination with Treponema framboesiæ killed at various degrees of temperature.[5] Parallel Wassermann and Kahn tests were made in some of these animals. The results of the tests show that there was a fair agreement between the results of the Wassermann and the Kahn tests, but the Wassermann test shows a stronger reaction than the Kahn test, and the quantitative relation between the number of vaccinations and the strength of the reaction is not as evident in the Kahn as in the Wassermann test. Unfortunately the Kahn test was performed only in animals immunized by 80° C. and 100° C. yaws vaccine. The results would probably be different had the Kahn test been investigated in those monkeys which received unheated yaws vaccine or vaccine killed at 60° C. Nevertheless these results show that the antigen responsible for positive Kahn reaction is likewise thermostable as it was not destroyed by heating for one hour at 80° C. or 100° C. (see Table 1).

In the majority of the animals in the experiment [6] in which repeated injections of normal skin tissue or inflammatory skin tissue from normal or yaws-infected monkeys were used the result of the Kahn test was negative. There were two plus minus lens reactions obtained on the first examination which became negative on the second test. One of the seven animals gave repeatedly a frankly positive Kahn test (+ + + +). After the infection with yaws treponema the Kahn test shows again a close agreement with the Wassermann reaction, but it gives a positive result, sometimes earlier sometimes later than the Wassermann test. In two cases the Wassermann test became positive following infection while the Kahn test remained negative (see Table 3).

In connection with the question whether the skin tissue itself or other tissues are the principal organs in which the Wasser-

[4] Philip. Journ. Sci. 35 (1928) 333.
[5] Schöbl, O. and B. Tanabe, antea 57.
[6] Miyao, I., antea 71.

mann reagin [7] is produced, the Kahn test was also performed simultaneously with the Wassermann test. The result of this experiment shows that following subcutaneous vaccination, both Wassermann and Kahn reagin are produced exclusively by the skin proper and not by lymphatic or muscle tissue as shown by the serological results in vaccination as well as revaccination. It can be seen from the results in Table 2 that monkey d–3 gave the same result and even more pronounced with the Kahn test than by the Wassermann test, whereas monkey d–4 remained negative with regards to the Kahn test but weakly positive with the Wassermann test.

It is noteworthy as evident from Tables 2 and 3 that some normal monkeys showed slightly positive Kahn test where the Wassermann test was regularly negative. However, this slightly positive Kahn test in normal animals had obviously increased after vaccination or after infection as can be seen in animal d–3, Table 2; and in monkeys R–3 and a–2, Table 3. Therefore, this slight handicap of Kahn test with respect to Wassermann test as encountered in some of the known normal monkeys by no means invalidated the experimental findings. As a matter of fact monkey d–4 of Table 2 showed doubtful precipitation which never increased but remained negative in all subsequent tests made after vaccination and revaccination and after infection in animals a–1 and Z–2 (Table 3) which have been previously and respectively immunized with inflammatory skin tissue from a normal monkey and from a yaws monkey. This seemingly false precipitation in the Kahn test may be attributed to the inherent properties of some particular monkey's serums. In this experimental work these doubtful positive results of Kahn test or Wassermann reaction occasionally encountered in normal animals can be disregarded in view of the rise in titre of the serums following vaccination with yaws vaccine or infection with yaws.

CONCLUSIONS

1. The experimental infection with yaws produces in Philippine monkeys positive Kahn test.

2. Positive results by Kahn test were obtained in Philippine monkeys by immunization with dead treponemas killed at various degrees of temperature.

3. The treponema antigen which produces positive Kahn test when injected to suitable experimental animals is thermostable.

[7] Miyao, I., loc. cit.

4. It shows signs of specific antigen.

5. The treponema antigen which produces a positive Kahn test is most likely identical with that which produces positive Wassermann.

6. There is an agreement between the results of Wassermann and Kahn tests with regard to serologic reactivity of tissues to the injection of this antigen.

ACKNOWLEDGEMENT

I wish to express my sincere thanks to Dr. R. L. Kahn, of the Michigan Public Health Laboratory, for his courtesy in sending me the antigen which I obtained through the kind services of Dr. E. B. McKinley, member of the Rockefeller Foundation.

TABLE 1.—*Showing the results of Wassermann and Kahn tests performed on yaws-vaccinated monkeys.*

[—, complete hæmolysis; ±, less than 25 per cent inhibition; +, 25 per cent inhibition; ++, 50 per cent inhibition; +++, 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done. For interpretation of Kahn test see text.]

Designation of monkey.	Vaccination.						Vaccine killed 1 hour at—	After vaccination.			
	Number.	Date.	Number.	Date.	Number.	Date.		Wassermann reaction before vaccination.	Date.	Result of— Wassermann reaction.	Result of— Kahn test.
W-57	1	III- 5-28	2	III-12-28	3	III-20-28	80° C.	—	IV- 7-28	+++	0
									V- 3-28	++	+
									V-28-28	—	—
W-58	1	III- 5-28	2	III-12-28	3	III-20-28	80° C.	—	IV- 7-28	+++	0
									V- 3-28	+	±
									V-28-28	—	—
W-59	1	III- 5-28	2	III-12-28	0	----------	80° C.	—	IV- 7-28	++	0
									V- 3-28	+	+
									V-28-28	±	—
									VI-21-28	±	—
									VII- 6-28	—	—
									VII-18-28	—	—
W-60	1	III- 5-28	0	III-12-28	0	----------	80° C.	=	IV- 7-28	+	0
									V- 3-28	±	±
									V-28-28	±	—
W-61	1	III- 5-28	0	----------	0	----------	80° C.	—	IV- 4-28	—	0
									V- 3-28	+	—
									V-28-28	+	—
									VII- 6-28	—	—
									VII-18-28	—	—
									VII-30-28	—	—

W-63	1	III- 5-28	2	III-14-28	3	III-20-28	[a] 80° C.	—	IV- 7-28	—	0
									V- 3-28	±	±
									V-28-28	—	—
									VII-18-28	—	—
									IX-18-28	—	—
W-64	1	III- 5-28	2	III-14-28	3	III-20-28	[a] 80° C.	=	IV- 7-28	±	0
									V- 3-28	+	—
									V-28-28	—	—
									VII-18-28	—	—
									IX-18-28	—	—
K-9	1	IV-11-28	1	IV-16-28	1	IV-27-28	100° C.	—	V-17-28	+	±
A-8	1	IV-11-28	1	IV-16-28	1	IV-27-28	100° C.	—	V-17-28	+	±
J-18	1	IV-16-28	1	IV-27-28	0	----------	100° C.	—	V-17-28	++++	+++

[a] Diluted.

TABLE 2.—*Showing the serologic results after subcutaneous, intraperitoneal, and intramuscular vaccination against yaws. Both Wassermann and Kahn reactions considered.*

Designation of monkey.	Date and modus of vaccination.			Before vaccination, VI-13-28.	Wasserman reaction Results and dates. After vaccination			Revaccination, VIII-4-28.	Wasserman and Kahn reaction after revaccination.	
	First, VI-14-28	Second, VI-22-28.	Third, VI-30-28.		VII-13-28	VII-27-28	VIII-2-28.		Wasserman reaction, VIII-16-28.	Kahn reaction, VIII-30-28
c-1	Intrap.	Intrap.	Intrap.	—	—	—	—	Intrap.	—	—
				—	—	—	—		—	—
c-2	do	do	do	—	—	—	—	do	—	—
				—	—	—	—		—	—
d-1	Intram.	Intram.	Intram.	—	—	—	—	Intram.	—	—
				—	—	—	—		—	—
d-2	do	do	do	—	—	—	—	do	—	—
				—	—	—	—		—	—
d-3	0	Subcut.	Subcut.	—	—	±	+	Subcut.	±	+
				±	++	++	++++		++++	+++
d-4	0	do	do	—	—	±	—	do	±	—
				±?	—	—	—		—	—

ª The marks above are for Wassermann reaction. The marks below are for Kahn test.

TABLE 3.—*Showing the result of Wassermann reaction and of Kahn test in monkeys immunized with normal and inflammatory tissues from normal skin of normal and yaws monkeys.*

[—, complete hæmolysis; ±, less than 25 per cent inhibition; +, 25 per cent inhibition; ++, 50 per cent inhibition; +++, 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done. For interpretation of Kahn test see text.]

Designation of monkey.	Material used for subcutaneous vaccination.	Date and result of Wassermann and Kahn reactions after immunization.		Date and result of inoculation with yaws.	Date and result of Wassermann and Kahn reactions after infection and superinfection with yaws treponemas.							
R-3	Normal skin from normal monkey	VI-20-28 [a]— ±1	VII-5-28 — —	VII-19-28 yaw	IX-3-28 — ±	IX-13-28 — +	IX-27-28 — ++	X-10-28 Dead	X-23-28 Dead	X-31-28 Dead	0	
R-4	Do	VI-20-28 — —	VII-5-28 — —	VII-19-28 yaw	IX-3-28 — ± 1	IX-13-28 — ±	IX-27-28 — +	X-10-28 — —	X-23-28 + +	X-31-28 — +	0	
S-4	Normal skin tissue from yaws monkey	VI-20-28 — —	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-23-28 + ∓	X 31-28 — —	0	
A-1	Inflammatory skin tissues from normal monkey	VII-2-28 — —	VII-16-28 — —	VII-31-28 yaw	IX-3-28 — —	IX-13-28 ++ —	IX-27-28 — —	X-10-28 — —	X-23-28 + —	X-31-28 ± —	0	
A-2	Do	VII-2-28 — +	VII-16-28 — ++	VII-31-28 yaw	IX-3-28 — ++++	IX-13-28 +++ ++++	IX-27-28 + ++++	X-10-28 +++ ++++	X-23-28 ++ +	X-31-28 + ∓	0	
Z-1	Inflammatory skin tissues from yaws monkey	VI-20-28 — —	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-10-28 — —	X-31-28 — —	XI-14-28 ± —	XI-7-28 — +
Z-2	Do	VI-20-28 — ± 1 ?	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-10-28 — —	X-31-28 — —	XI-14-28 ± —	XII-7-28 — —

[a] The marks above are for Wassermann reaction. The marks below are for Kahn test.

SUMMARY OF SEROLOGIC STUDIES IN EXPERIMENTAL YAWS [1]

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It appears from the experiments described in the preceding papers that the reagin of the Wassermann reaction is a true antibody of its kind. It occurs in the blood not only as a result of infection with treponemas but also as a result of subcutaneous injections of killed treponemas. It is therefore a direct serologic response to the antigen contained in the treponemas and not merely a consequence of interaction between the viable treponemas and the tissues. The "in vivo antigen" of the Wassermann reagin is a substance which can be liberated from the treponemas and which shows a high degree of thermostability and is specific. The same "in vivo antigen" that produces positive Wassermann reaction is responsible for the appearance of other serologic reactions which are based on the phenomenon of precipitation of the "in vitro antigen" by the serum of the tested subject (Kahn). The strength of the Wassermann reaction stands in direct proportion, but the pre-Wassermann period in inverse proportion, to the amount of the treponema antigen injected. The serologic response to repeated vaccination with killed treponemas is the same as the response to repeated infections interrupted by cures.

Following subcutaneous vaccination the skin proper and not the lymphatic tissues or the muscles are responsible for the production of the antibody detectable by the usual serologic reactions. Intraperitoneal and intramuscular vaccination failed to produce positive serologic reactions. The serologic reactions and the antitreponematous immunity are not directly dependent on each other but are dependent on a common factor that is the "in vivo antigen." Consequently these two phenomena show a certain parallelism. The strength of the Wassermann reaction in the early stage of the disease indicates the severity of the infection at that time, and therefore it indirectly prognosticates

[1] Received for publication, December 14, 1928.

the early development of the subsequent immunity. But the immunity continues to exist after the serologic reactions have vanished. However, the infection may be so mild that no appreciable serologic change will take place and yet immunity may set in even though delayed. If a persistent positive serologic reaction establish itself in the resistant stage of yaws following infection it may last for a long time without any apparent lesion or latent infection.

IMMUNOLOGIC RELATION BETWEEN YAWS AND SYPHILIS

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FOUR PLATES

The experiments performed on monkeys in the past with the view of studying the immunologic reciprocity between syphilis and yaws are open to serious criticism.

As few as they have been the experimenters, with the exception of Levaditi and Larier,[1] have convinced themselves that neither syphilis immunizes against yaws nor yaws against syphilis. The study of immunity in syphilis was stranded on the rock of "latent infection," and the field of immunity to yaws in monkeys, the most suitable experimental animals, lay idle for more than twenty years. A brief inspection of the experiments on monkeys as published in the early era of experimental syphilis will reveal to anyone that serious omissions have been made in the arrangement of the experiments.

1. There is little or no evidence afforded in these experiments that the viability of the material used for reinoculation was tested on normal control animals of the same kind.

2. There is no evidence afforded in the experiments that the disease first conveyed to the animals produced immunity to itself in the same animals before the immunity to the other disease was tested.

3. Neither the time factor in the development of immunity nor the quantitative degree of immunity was properly considered. It was apparently taken for granted that the syphilitic monkeys used in these experiments were immune to syphilis at the time they were inoculated with yaws because other syphilitic monkeys which were not used in the same experiments were found on other occasions to be immune to syphilis about that time after the first inoculation.

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[1] Ann. de l'Inst. Pasteur 22 (1908) 263.

Furthermore, it was evidently taken for granted that the time necessary for the development of immunity to yaws is the same as that in syphilis.

Recent experiments[2] have shown that yaws monkeys (local yaw) were without exception inoculable with yaws for five months, after the first inoculation. During the sixth month a certain percentage of the animals was found resistant. Animals superinfected after the sixth month were without exception found to be immune. Yaws monkeys with generalized yaws were found immune earlier than those with local yaws, and in animals with late ulcerative forms the immunity was found much delayed. This shows quantitative degrees of immunity in experimental treponematoses a fact which has never been considered.

Therefore, the minimum time limit at which the majority of yaws monkeys can be reasonably expected to have developed a high degree of immunity to yaws is seven months after the date of successful inoculation, no less than two hundred ten days.

Equipped with this recently acquired knowledge with regard to immunity to yaws in monkeys we can see at a glance that the past experimental evidence on monkeys is reduced to one experiment on one monkey, the only experiment in which the interval between the inoculations was more than two hundred ten days (syphilis-yaws). This single case is not convincing in view of the fact that monkeys with late ulcerative yaws as a consequence of superinfection developed immunity late. One of them was successfully inoculable seventeen months after the original inoculation. The experiment of Levaditi and Larier, who were the only ones to conclude from their experiment the existence of cross immunity between syphilis and yaws, needs confirmation, particularly in view of the fact that only one test for immunity was made.

For the sake of clearness the results of previous experiments on monkeys as tabulated by Chesney (Table 1) are reproduced, together with our tabulated experiments on immunity to yaws in monkeys.[3]

With such meager experimental evidence on hand, concerning the cross immunity between yaws and syphilis, we have decided to attack the problem by experiments on Philippine monkeys.

[2] Schöbl, Philip. Journ. Sci. 35 (1928) 279–291.

[3] Philip. Journ. Sci. 35 (1928) 285, Table 10; 286, Tables 11 and 12.

Monkeys successfully inoculated with yaws more than twelve months previous to the test for cross immunity and which were proven to be immune to yaws were inoculated with syphilis.

BRIEF ACCOUNT OF THE STRAINS OF YAWS AND SYPHILIS USED IN CROSS-IMMUNITY EXPERIMENTS

THE STRAIN OF YAWS

The strain of yaws used in the experiments concerning the immunological relation between yaws and syphilis was the Philippine strain Kadangang named after the patient from whom it was isolated March 4, 1925. Since that time the strain has been passed from monkey to monkey. During this four-year period of continuous passages from monkey to monkey, no sign of attenuation has been noted, and at the time of writing the strain produces just as vigorous lesions as it did during the the first year after isolation from the patient. On Plate 1 is shown a yaws' lesion that appeared on the eyebrow and the nose of an experimental animal in consequence of superinfection with yaws. This local exacerbation was followed in time by numerous metastatic lesions as can be seen in Plate 2. We have selected this strain of yaws for our experiments because of its high virulence as well as our knowledge of the strain. One reads in the literature complaints of the difficulty of maintaining strains of yaws in rabbits. We have had no difficulty in maintaining yaws strains in monkeys. Apparently in this as well as in other respects the Philippine monkey is a far better experimental animal than the rabbit as far as yaws is concerned.

THE STRAIN OF SYPHILIS

The literature concerning syphilitic lesions produced experimentally in monkeys is fairly voluminous. However, the animals are designated without giving any information as to the locality from which they come. Most authors are satisfied with calling the monkeys macacus, cynomolgus, etc. It became necessary, therefore, for the study of syphilis with regard to immunity and its relation to yaws in Philippine monkeys to establish whether or not the animal experimented on is susceptible to syphilis, and the extent of the experimental syphilitic infection in this animal. There appears to be a general belief permeating the literature on experimental treponematoses that the suitability of an experimental animal is determined by its position

in the zoölogic system of classification. There is no evidence in the literature that a comparative study of treponematoses by appropriate experimental methods has ever been made, but the dogma as to the differences between higher apes and lower monkeys with regard to suitability for experimentation is perpetuated. As to yaws the experiments found in the literature, one on an orang-utan and a few isolated experiments on chimpanzees, contribute nothing more to our knowledge of the disease than the early experiments of Ashburn and Craig[5] on Philippine monkeys, and far less than our experiments by more appropriate procedure of experimentation on *Cynomolgus philippinensis*.[6] A a matter of fact the first animal ever successfully inoculated with syphilis was the rabbit. The confusion and misconception of immunity in experimental syphilis is not so much due to the unsuitability of the rabbit as an experimental animal as to the conventional method of experimentation and the interpretation of the results based on concepts of clinical traditions and on early theories of immunity. Indeed, the backbone of all this misconception, the theory of latent infection as a cause of resistance in treponematoses, was created as an explanation of experimental findings made on higher apes.

We believe that a good deal can be achieved in the advancement of our knowledge of these diseases by continuing to experiment on lower animals, without the fear that the disease may run a different course in an experimental animal than in man. The full possibilities of a given experimental animal must be discovered by appropriate methods of experimentation and the results obtained must be properly weighed without interference of past and present theories and traditions.

In these experiments we have chosen a well-known laboratory strain of syphilis. This was done for two reasons: First, that the objection may not be raised abroad that we have mistaken clinically yaws for syphilis, working as we are in a country where both diseases can be found, and that we isolated a strain of yaws believing it to be syphilis; and, second, because the strain of syphilis used by us is well known to laboratory men in the United States and Europe, and has been widely used in experiments on rabbits. Our findings, therefore, can be related to the results of others on other kinds of animals and may become more helpful in the interpretation of the infection and immunity in experimental syphilis.

[5] Philip. Journ. Sci. § B 2 (1907) 441–465.
[6] Philip. Journ. Sci. 35 (1928) 135.

Through the kindness of Col. J. F. Siler, United States Army Medical Corps, War Department, Washington, D. C., we were able to secure the well-known laboratory strain that was isolated by the late Lieutenant Colonel Nichols, United States Army. We wish to thank the Director and the staff of the Army Medical School Laboratories, Washington, D. C., for their courtesy in sending us rabbits inoculated with the Nichols strain of syphilis. Thanks are due to Major Simmons, Captain St. John, and Captain Reynolds, of the United States Army Medical Department Research Board, Manila, who were directly instrumental in the safe delivery of the Nichols strain.

The Nichols strain is well known to all who are engaged in the experimental study of syphilis and needs very little comment. It may be well, however, to mention for those who have not worked with this strain that it has been passed through numerous rabbits and that it produces 100 per cent takes in rabbits in the form of a typical syphilitic orchitis and chancre (Plate 3) with numerous treponemas in the lesions at a certain stage of the infection. The strain reached us in May, 1928, and immediately transfers were made to rabbits to assure the maintenance of the strain. Inoculations were performed on Philippine monkeys with the view to study the lesions that may be produced upon single inoculation with this strain in this kind of animals.

THE PROCEDURE OF INOCULATION OF MONKEYS

Using materials from the chancre or the orchitis of the syphilitic rabbit as a seed, we inoculated monkeys on the eyebrows and the scrotum, by intracutaneous injection. This was done particularly for the reason that the intracutaneous injection was used in our work with yaws and that it is a close approximation to the natural mode of infection with this disease in man. It yielded 100 per cent results. Some few monkeys were inoculated by intratesticular injection to test whether or not syphilitic infection in Philippine monkeys behaves similarly to that in rabbits in this respect.

THE PRIMARY SYPHILITIC LESION IN PHILIPPINE MONKEYS FOLLOWING INTRADERMAL INJECTION OF SYPHILITIC MATERIAL DERIVED FROM RABBITS INFECTED WITH NICHOLS STRAIN AND CONTAINING NUMEROUS TREPONEMAS LUIS

The first sign of the primary syphilitic lesion in Philippine monkeys is a slightly elevated superficial papule showing typical copper-colored discolorization on the light-colored skin of the

monkey's scrotum (Plate 4, fig. 1). This papule gradually becomes more and more elevated until a typical almost bluish-red papule develops at the place on the scrotum where the material was inoculated, as can be seen on Plate 4, fig. 2. The papule becomes elevated before it spreads out, is firm to the touch, and soon a deep induration at the base takes place. Upon incission of such a well-developed papule a clear serous fluid escapes. Whether left undisturbed or incised and scarified for the purpose of searching for treponemas the papule on the scrotum was never observed to develop a crust or an ulcer as observed in rabbits inoculated with the same strain of syphilis (Plate 3, fig. 2). In the course of further development this papule spreads into the depth of the skin with the induration and œdema surrounding it. The deep hard induration persists for varying lengths of time, and ultimately softens and disappears.

If the syphilitic material from the rabbit is injected subcutaneously a deep hard induration develops without the formation of a papule.

Inoculation on the eyebrows never produced a typical papule as observed on the scrotum, but a hard induration evidently involving all layers of the skin. Superficial ulcerations were sometimes observed on the eyebrows, never on the scrotum.

The few instances in which Philippine monkeys were inoculated with syphilitic material containing treponemas by intratesticular inoculation gave at times a slight induration of the testis, but a typical orchitis as we are accustomed to find in rabbits or a chancre on the scrotal skin was never observed (Plate 3, figs. 1 and 2).

The lesions so far described arose as a consequence of single inoculations of Philippine monkeys with syphilitic material. They were characterized by the fact that only occasionally treponemas were found within the lesions and then in much smaller numbers than regularly found in a yaws lesion in the same kind of animal.

INCUBATION AND DURATION OF INITIAL SYPHILITIC LESION IN PHILIPPINE MONKEYS

The average incubation period, that is, the time between the inoculation and the first appearance of a suspicious lesion, was approximately three weeks. However, the lesion sometimes was noticed earlier (two weeks) and sometimes later (four and a half weeks). The duration of the hard deep infiltration lasted

at times for several weeks, as long as twelve weeks. After this length of time the lesion was no longer perceptible by palpation. When the lesion healed, there being no ulceration, it healed without any trace whatsoever on the skin. Not infrequently the initial papule healed without developing further. From this observation on more than twenty Philippine monkeys it can be concluded that the Philippine monkey is not a very promising animal for syphilis experimentation, yet a definite, local, clinically characteristic lesion develops in this animal. Since the treponemas in the primary lesion are few and only occasionally found, it would be difficult to judge the result of immunization and of immunity to syphilis in these animals by the character or extent of the local lesion alone. Another sign of infection had to be looked for to enable us to interpret the findings of the infection as a test for immunity. It is well known that Treponema luis survives in the popliteal gland in syphilitic rabbits for considerable time after the local lesion has healed. It was, therefore, of importance to decide the question whether in Philippine monkeys Treponema luis remains at the place of inoculation or invades other body tissues. It was decided to search for the treponemas in the lymphatic glands corresponding to the initial lesion. The duration of the lesion was on the average five weeks, the longest eight, and the shortest two weeks.

INVESTIGATION CONCERNING THE SURVIVAL OF TREPONEMA LUIS IN THE INGUINAL LYMPH GLAND OF PHILIPPINE MONKEYS CORRESPONDING TO THE PRIMARY LESION OR POINT OF INOCULATION WITH VIRULENT TREPONEMA LUIS

The procedure used in this investigation was as follows:

At various intervals of time after the healing of the initial lesion the inguinal lymph gland corresponding to the side of the scrotum where Treponema luis was injected was surgically removed, triturated in a sterile mortar, suspended in a small amount of salt solution, and injected intratesticularly into male rabbits. The results are given in Table 1.

This table shows that five of five normal control monkeys inoculated with syphilis by intracutaneous injection of syphilitic material harbored viable Treponema luis in the inguinal gland corresponding to the place of inoculation on the scrotum. Another monkey inoculated with the same strain of syphilis but by intratesticular injection also harbored the treponemas in the regional lymph gland. The lymphadenectomy in these animals

was made two, three, four, and five months after the inoculation. The experimental syphilitic skin lesions in these monkeys were of various intensities. Treponemas could be found in but few of the lesions; the search by microscope in the greater number of them failed to reveal treponemas. Contrary to the findings in yaws lesions of monkeys the treponemas found in the syphilitic initial scrotal lesion of the same kind of animals were very few if found at all. In spite of that Treponema luis reached the lymph gland with great regularity and survived there long after the lesion had healed. For comparison and for the convenience of the reader we reproduce the table from a previous publication which shows the results of lymph-gland transplants from yaws-infected monkeys to normal monkeys.[7]

CONCLUSIONS DRAWN FROM PRELIMINARY EXPERIMENTS CONCERNING SYPHILITIC INFECTION IN PHILIPPINE MONKEYS

1. Contrary to the claim in the literature[8] Philippine monkeys, *Cynomolgus philippinensis,* are susceptible to syphilis (Nichols strain).
2. The syphilitic lesion produced by single experimental inoculation using the intracutaneous injection on the scrotum is a typical copper-colored papule with indurated base. It may heal at this stage or progress to a sclerosis.
3. A chancre was never observed to develop on the scrotum in Philippine monkeys either by intradermal or intratesticular inoculation with the Nichols strain, which, as is well known, produces typical syphilitic orchitis and chancre in rabbits as a consequence of intratesticular inoculation (Plate 3).
4. On the eyebrows hard induration developed consequent to the intradermal inoculation with the Nichols strain of syphilis. At times flat shallow defects were observed which sometimes contained a good number of treponemas.
5. The incubation of the lesions thus produced averaged three weeks, the shortest was two weeks, and the longest four and a half weeks.

THE NATURE OF IMMUNITY IN TREPONEMATOSES

Whether stress is laid on phagocytosis, agglutination, bacteriolysis, or other demonstrable phenomena of immunity the

[7] Philip. Journ. Sci. 35 (1928) 302, Table 17.

[8] Phehn, Ueber den gegenwärtigen Stand der Framboesie-Frage, Beih. z. Archiv für Schiffs- und Tropen-Hygiene 16 (1912) 321.

traditional and prevailing concept of immunity is that of curative immunity. The bacteria are immobilized, dissolved outside or inside of leucocytes not only in vitro but also in vivo. These are the original theories of immunity and defense against infections. However, the painstaking experiments of Oskar Bail, Edmund Weil, and others of their school showed that resistance can be induced by immunization with sterile exudates produced by mass infection with virulent bacteria of septicæmic proclivities. Thus achieved immunity localizes the infection at the places of inoculation and prevents the growth of bacteria as well as the invasion of body tissues by the infectious agent without injuring its viability or virulence. Further advancement in immunology was made by v. Pirquet's investigations on allergy. The last two steps in the progress of our knowledge of bacterial immunity led to our concept of immunity in treponematoses.[9]

As we have pointed out, there exists a fairly constant and direct[10] relation between the vigor of early yaws lesions and the number of treponemas found therein. The resistance of the body tissues, which is apparent by a partial or complete inhibition of development of early yaws lesions, prevents the growth and multiplication of the treponemas at the point of intradermal inoculation. The treponemas do not multiply sufficiently to invade the lymphatic system, consequently they never reach the blood stream. The development of a local initial lesion is prevented by this condition and the generalized infection is made impossible. This statement refers to the cutaneous portal of infection and not to intravenous inoculation of treponemas, an artificial condition by which the main barriers of defense, the skin and the lymphatic system, are set aside and only the end part of the whole process of infection is imitated. Likewise the intratesticular inoculation, as useful a laboratory method as it is, cannot be accepted as an approximation, in an experiment, of the way in which man acquires syphilis except under most extraordinary circumstances. Bearing in mind the law of sequence of Brown and Pierce we may fear different conditions with regard to immunity in animals, inoculated by the intratesticular method, from the immunity which develops as a consequence of an infection through the natural portal in

[9] Philip. Journ. Sci. 35 (1928) 279–297.
[10] Philip. Journ. Sci. 35 (1928) 257.

man, that is the integument. The frequent occurrence in a rabbit inoculated with syphilis by intratesticular injection that orchitis develops long before a chancre hints at a reverse sequence in pathogenesis of experimental syphilis under such artificial conditions. Lesions develop in an internal organ prior to those on the integument in such a case.

When Treponema framboesiæ has reached the lymphatics, and after the skin lesions of the monkey have healed, it does not survive there or in tissues other than the skin for a sufficiently long time to maintain the infection. This has been demonstrated in monkeys.[11] In syphilitic monkeys, as in rabbits, Treponema luis reaches the lymph glands regularly and survives there long after the lesion has healed not withstanding the insignificant local syphilitic skin lesions that develop in Philippine monkeys as compared with the intensive and extensive yaws lesions in the same kind of experimental animal. This is the fundamental biologic difference between the two treponemas, and it serves as a rational explanation of the clinical differences between yaws and syphilis with reference to lesions in internal organs, the central nervous system, the cardiovascular system, and consequent to the latter the difference in congenital transmission of the two diseases, all of which manifestations are found in syphilis but are absent from yaws.

To test the truth of this concept deduced from our early studies of experimental yaws which prompted us to state on another occasion that immunity in treponematoses resembles antiaggresin immunity, and to corroborate our findings on syphilitic skin lesions in nonimmune and yaws-immune monkeys we have undertaken the following experiment.

We selected a group of thirteen monkeys which had gone through yaws infection, developed local yaw, healed long ago, and had been found repeatedly immune to yaws. In the test for immunity to yaws these monkeys gave negative results while normal control animals inoculated with the same material at the same time developed yaws at the places of inoculation. The thirteen monkeys thus found to be immune to yaws were inoculated by intradermal injection of syphilitic material secured from a rabbit. Another group of five normal monkeys was also inoculated at different times in the same way with the same strain of syphilis.

[11] Philip. Journ. Sci. 35 (1928) 257.

The differences in size, character, and duration of the syphilitic lesions in the animals immune to yaws as a consequence of local yaw produced years ago, and the syphilitic lesions which resulted as a consequence of inoculation into nonimmune normal control monkeys were quite marked. The yaws-immune animals developed small short-lived lesions resembling luctin reaction, or no lesions.

Treponemas were not found microscopically in the abortive syphilitic lesions which developed in yaws-immune animals. However, they were not found regularly by microscopic examination in typical syphilitic lesions of nonimmune monkeys. Furthermore, the objection may be raised that the reading of the resulting lesions may be subject to personal equation. Another corroborative and more-convincing method had to be resorted to.

Consequently search was made for viable Treponema luis in the lymph glands corresponding to the place of inoculation with syphilis. Monkeys immune to yaws due to infection, and nonimmune monkeys were included. Transplants of the lymph glands by intratesticular injection to the rabbits were made some time after the local syphilitic lesions in the nonimmune control monkeys had healed. Two rabbits were inoculated with the lymph glands from each monkey so as to safeguard against untimely death of the rabbits. The greatest part of the rabbits were observed for five months or more. It can be seen from Table 2 that every one of the control animals harbored viable Treponema luis in the lymph glands after the initial syphilitic lesion healed. It is further shown that none of the thirteen yaws-immune monkeys contained Treponema luis in the lymph glands at any time after the intracutaneous infection with syphilis. There was a striking difference in size, color, and consistency of the lymph glands in the yaws-immune and the control monkeys. The lymph glands in the immune animals had a normal appearance while those in the control monkeys were large, firm, and grayish.

DISCUSSION

In yaws as in syphilis coincident immunity and infection exist, but in experimental frambœsia the treponemas do not survive in the lymphatic system after the lesions have healed as they do in syphilis. Consequently, in yaws some time after healing the infection ceases to exist and the immunity persists.

The presence of treponemas in the lymph glands is rightfully considered as an indication of a tendency of the infection to become generalized. In experimental syphilis it appears to be a more constant condition than in yaws. However, it cannot be taken as an indication of the degree of subsequent immunity. In experimental local yaws viable treponemas may or may not be demonstrable in the lymph gland corresponding to an active yaws lesion, but whether or not treponemas are present in the lymph gland the time necessary for the development of immunity is the same. The generalized skin manifestations of yaws infection, on the contrary, serve as a reliable sign of an early onset of high-grade immunity. Evidently the lymphatics do not participate to such an extent as the skin in building up immunity in yaws. This immunity is not treponemocidal and the survival of Treponema luis in the lypmh glands is a phenomenon of its biologic property which Treponema framboesiæ lacks. In spite of the long persistence of Treponema luis in the lymph glands of rabbits or monkeys after the initial lesion has healed, the animals are immune to super- or reinoculation and no relapses of clinical manifestations take place.

Following an inoculation with syphilitic material the treponemas reach the lymph gland and other tissues before the initial lesion has healed and long before the immunity has developed. When immunity develops it does not destroy the treponemas but keeps them at bay wherever they are found at that time. When immunity in our experimental animals was fully established by yaws infection prior to inoculation with syphilis Treponema luis never reached the lymph glands nor even multiplied at the point of inoculation. Consequently syphilitic initial lesions failed to developed in the skin of yaws-immune monkeys, or only a short-lived, feeble swelling developed which resembled the efflorescence seen in positive luetin reaction or the immunity reaction following inoculation with yaws performed in yaws-immune monkeys. The treponemas were prevented from multiplication at the point of inoculation and never reached the first lymph glands.

The evidence derived from the experiments herein presented augments our knowledge of the fundamental principles underlying the treponematous infections. It confirms our supposition concerning immunity in treponematoses. These fundamentals should always be borne in mind whenever an interpretation of any phenomenon or manifestation in the course of these diseases is attempted.

Thus far in our investigations the fundamental facts and principles are:

1. The treponema of syphilis is far more resistent to adverse conditions prevailing outside the tissues of the host than the treponema of yaws.

2. The treponema of syphilis is panblastotropic. It can invade, multiply, and colonize all tissues. It does that with a mesoblastic preference, and according to the law of sequence. It survives and produces lesions in the various tissues. The consequence is syphilitic manifestations on the skin, the mucous membranes, the internal organs, and the nervous tissue. Treponemas of syphilis invade the cardiovascular system and consequently the placenta, resulting in congenital syphilis.

The treponema of yaws is epiblastotropic. It invades, colonizes, and produces lesions only in certain tissues, particularly the skin. Its invasion may extend to mucous membranes by extension per continuitatem from the skin. It lacks the mesodermic preference of the treponema of syphilis. Consequently the internal organs, the nervous tissue, and the cardiovascular system remain unaffected and the disease is not congenital.

3. Immunity exists in treponematous infections and its mechanism is the same as that of antiaggressive immunity found in certain bacterial infections. It localizes the infection and keeps

TABLE 1.—*Showing the results of cross inoculation of monkeys with yaws and syphilis.*

[Tabulated by Alan Mason Chesney, Medicine Monographs Immunity in Syphilis Vol. 12:63.]

Author.	Animal.	First inoculation.	Incubation period.	Interval between inoculations.	Second inoculation.	Result.	Incubation period.
			Days.	*Days.*			
Neisser, Baermann and Halberstadter.	Mac. cyn	Yaws	46	32	Syphilis	Positive	21
	Mac. nig	Syphilis	26	41	Yaws	Positive	34
Halberstadter	Mac. cyn	Yaws	49	73	Syphilis	Positive	22
	Mac. nem	Syphilis	36	296	Yaws	Positive	46
	Mac. cyn	Syphilis	52	58	Yaws	Positive	42
Castellani	Mac. pil	Yaws	?	(a)	Syphilis	Positive	26
	Mac. cyn	Yaws	32	101	Syphilis	Positive	42
Levaditi and Nattan-Larier.	Mac. rhes	Syphilis	15	74	Yaws	Negative	--------
	Mac. cyn	Syphilis	20	91	Yaws	Negative	--------
	Mac. cyn	Syphilis	22	91	Yaws	Negative	--------
	Mac. rhes	Syphilis	19	95	Yaws	Negative	--------
	Bon. chin	Syphilis	28	110	Yaws	Negative	--------

[a] About 136 days.

the treponemas wherever they happen to be at the time of the onset of immunity. The immunity prevents the treponemas from further invading the tissues without injuring their viability or virulence. The tissues may at times react excessively in the attempt to suppress the invader. Late so-called tertiary lesions are the result thereof. Quantitative degrees of immunity exist.

4. Biologic healing of the lesions is independent of the immunity. There are reliable signs indicating that leucocytes play an important part in the destruction of treponemas and consequently in the spontaneous healing of lesions.

TABLE 10.—*Showing the development of immunity in yaws-infected Philippine monkeys.*

(Philippine Journal of Science, Vol. 35, No. 3, March, 1928, p. 285.)

[—, negative take; +, positive take; ±, feeble take.]

Monkey No.	Months after original inoculation.													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
L-6	+													
M-5	+													
T-4	+													
J-13	+													
A-5		+												
D-10		+												
G-7		+		+	±	—								
F-13		+		+										
E-13		+				+								
K-3		+												
L-5		+												
K-2			+		+		—		—					
B-1			+			+				—		—		
B-2			+			+				—		—		
B-3			+				—		—					
H-17				+		—								
J-11				+		—								
F-12				+		—								
C-2				+		—								
P-10				+				—	—	—				
M				+										
S-b				+			—							
O-b						—		—						
F-11						—								
M-3						—		—						
M-2						—								
A-3							—					—		
D-9							—		—					
A-2								—		—		—		—
H-16-b								—		—				
D-8											—		—	
L-4												—		—

TABLE 11.—*Showing the development of immunity in monkeys with generalized yaws.*

(Philippine Journal of Science, Vol. 35, No. 3, March, 1928, p. 286.)

[+, positive take after superinfection; —, negative take after superinfection; exac, exacerbation; gen, generalization; reg. met, regional metastases.]

Monkey No.	Result of first inoculation	Months after original inoculation.																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
P-8	Initial local yaw				+	gen			—												
N-8	do		exac	reg. met	gen		—			—											
T-1	do	+		exac	—, gen			—													
G-6	do		+—, exac	—, gen	—																
C-3	do				+	exac gen	—														
E-15	do	+			exac	gen			—												

[a] The symbols are placed in the months in which the superinfection, the exacerbations, or the generalization took place.

TABLE 12.—*Showing the development of immunity in monkeys with late ulcerative lesions.*

(Philippine Journal of Science, Vol. 35, No. 3, March, 1928, p. 286.)

[+, positive take; ±, feeble take; —, negative take.]

Monkey No.	Result of first inoculation.	Months after original inoculation.																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C-1	Initial local yaw	+														+, ulcer				±	
J-10	do				+, ulcer						±										
H-18	do		+		+, ulcer	—															

TABLE 17.—*Showing the results of lymph gland inoculation in Philippine monkeys.*

(Philippine Journal of Science, Vol. 35, No. 3, March, 1928, p. 302.)

[+, positive; —, negative; tr., treated with neosalvarsan.]

Recipient monkey.	Lesion.			Treponemas in lesion.	Result.		Donor monkey.
	Active.	Healing.	Healed.		Microscopic.	Take.	
R-2	+	—	—	+	—	—	T-13
R-2	+	—	—	+	—	—	Y-2
R-2	+	—	—	+	—	—	H-21
K-7	+	—	—	+	—	+	J-15.
A-6	+	+	—	+	—	+	B-5
P-14	+	—	—	+	—	—	A-7
N-15	+	+	—	+	—	—	B-5
L-7	—	+	—	+	—	+	G-9
Y-5	+	+	—	+	—	—	A-6
Y-5	+	—	—	+	—	—	O-d
Y-5	—	—	+	—	—	—	B-6
Y-4	—	—	+	—	—	—	P-13
Y-4	—	—	+	—	—	—	A-7
Y-4	+	—	—	+	—	—	G-10
Y-6	+ late	+	—	—	—	—	H-18
Y-6	+ tr	—	—	+	—	—	Baby I
Y-3	—	—	+ tr	—	—	—	B-K-3
Y-3	—	—	+ tr	—	—	—	B-K-2

TABLE 2.—*Showing the results of inoculations with syphilis performed on normal monkeys. The results of tests for the presence of viable treponema of syphilis in the lymph glands is also shown.*

[+, typical lesion; —, no lesion. The months are indicated by roman numerals, the days and years by arabic figures.]

Designation of monkeys.	Infected with syphilis.	Appearance of syphilitic lesion.	Lymph gland inoculation to rabbit.		Remarks.
			Date.	Result.	
Sy-1	V-16-28	+ VI-19-28	IX- 8-28	+	Intracut.
Sy-3	VI-13-28	+ VI-26-28	IX- 8-28	+	Intracut.
Sy-2	V-24-28	----------	X-22-28	+	Intratest.
Sy-5	VI-15-28	+ VI-26-28	X-22-28	+	Intracut.
Sy-6	VI-15-28	+ VI-26-28	X-22-28	+	Intracut.
K-11	IX-13-28	+ X- 3-28	XI-12-28	+	Intracut.

SUMMARY

Philippine monkeys that have gone through yaws infection produced by the Kadangan strain and found immune to yaws by repeated inoculations with homologous strain were found immune to cutaneous inoculation with the Nichols strain of syphilis.

CONCLUSIONS

A high degree of immunity to yaws protects against cutaneous infection with syphilis in Philippine monkeys.

TABLE 3.—*Showing the results of inoculations with syphilis performed on yaws-immune monkeys. The results of the tests for the presence of viable treponema of syphilis in the lymph glands are also recorded.*

[+, typical lesion; ±, immunity reaction; —, no lesion.]

Designation of monkey.	Infected with yaws.		Infected with syphilis.		Lymph gland transplants.		Rabbit.	
	Date.	Result.	Date.	Result.	Date.	Result.	Lived May 15, 1929.	Died.
J-11	III-19-26	+	VI-15-28	±	XI-19-28	—	one	I-14-29 one
	VII- 6-26	+						
	IX-29-26	—						
	IV- 4-27	—						
	III-26-28	—						
	I-11-29	—						
L-5	VII-16-26	+	IX-13-28	—	XI-16-28	—	one	II-11-29 one
	IX-29-26	+						
	III- 8-27	—						
	III-26-28	—						
L-6	XI-15-26	+	VIII-31-28	—	X-24-28	—	two	
	XII-27-26	+						
	VII-20-27	—						
	III-26-28	—						
D-8	IV-25-25	+	VI-15-28	±	XI-12-28	—	two	
	III-15-26	—						
	V-14-26	—						
	IV- 4-27	—						
	II- 4-28	—						
	I-11-29	—						
O-c	VII-27-26	+	IX-13-28	±	XI-16-28	—		XII-12-28 XII-10-28
	IV- 4-27	—						
	III-26-28	—						
	I- 8-29	—						

TABLE 3.—*Showing the results of inoculations with syphilis performed on yaws-immune monkeys. The results of the tests for the presence of viable treponema of syphilis in the lymph glands are also recorded*—Continued.

[+, typical lesion; ±, immunity reaction; —, no lesion.]

Designation of monkey.	Infected with yaws.		Infected with syphilis.		Lymph gland transplants.		Rabbit.	
	Date.	Result.	Date.	Result.	Date.	Result.	Lived May 15, 1929.	Died.
J-16	XI-5-26	+	VIII-31-28	—	XI-19-28	—		XI-20-28 I-21-29
	XII-27-26 Treatment; 0.08 gms neosalvarsan.							
	VII-18-27	+						
	III-26-28	—						
T-4	VII- 2-26	+	IX-13-28	—	XI-16-28	—		XII- 3-28 XII-10-28
	VIII-20-26	+						
	III- 8-27	—						
	III-26-28	—						
	I- 8-29	—						
K-7	I-15-27	+	VI-15-28	—	XI-12-28	—	two	
	III-26-28	—						
	XII-28-28	—						
Y-4	V-31-27	+	VIII-30-28	±	X-24-28	—	two	
	III-27-28	—						
	XII-28-28	—						
B-6	IV-12-27	+	VIII-30-28	—	XI-12-28	—	two	
	I-24-28	—						
	XII-28-28	—						
J-15	XI- 5-26	+	VIII-31-28	—	XI- 9-28	—		XII-10-28 XII- 3-28
	XII-22-27	—						
	III-26-28	—						
A-6	I- 6-27	+	VIII-31-28	±	XI-19-28	—	two	
	III-15-27	+						
	I-23-28	—						
	IV-11-28	—						
H-20	XI- 8-26	+	VIII-31-28	—	X-24-28	—	two	
	XII-27-26	+						
	III-26-28	—						
	I- 8-29	—						

ILLUSTRATIONS

PLATE 1

Showing an extensive and intensive local yaws lesion. The lesion was produced with a strain of yaws (Cadangan) that has been passed through monkeys exclusively for four years.

PLATE 2

Showing multiple metastatic yaws lesions produced in Philippine monkey with a strain of yaws (Cadangan) that has been passed through monkeys exclusively for four years.

PLATE 3

Showing typical syphilitic lesions produced in rabbits with Nichols strain of syphilis.

Fig. 1. Orchitis.

2. Bilateral orchitis and chancre on the left side of the scrotum.

PLATE 4

Showing initial syphilitic lesion in Philippine monkey produced by intradermal injection of syphilitic material (Nichol's strain).

Fig. 1. Initial papule on the left side of scrotum.

2. Fully developed sclerosis on the left side of the scrotum surrounded by deep œdema of the skin.

PLATE 1.

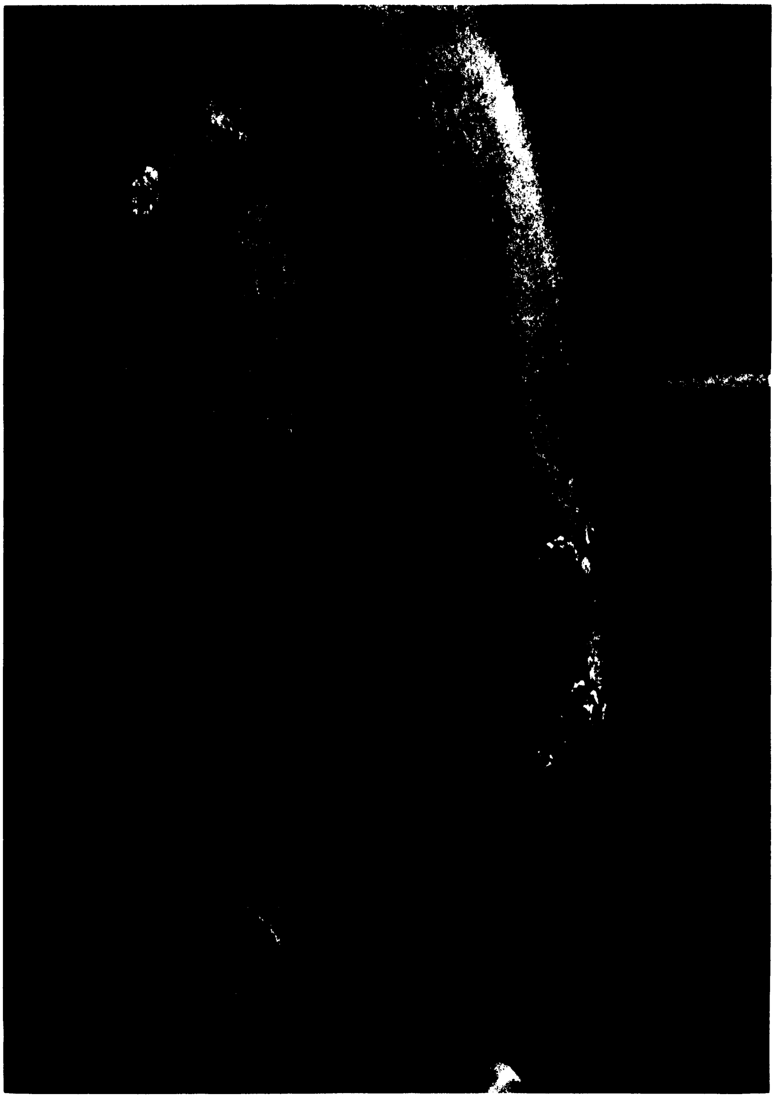
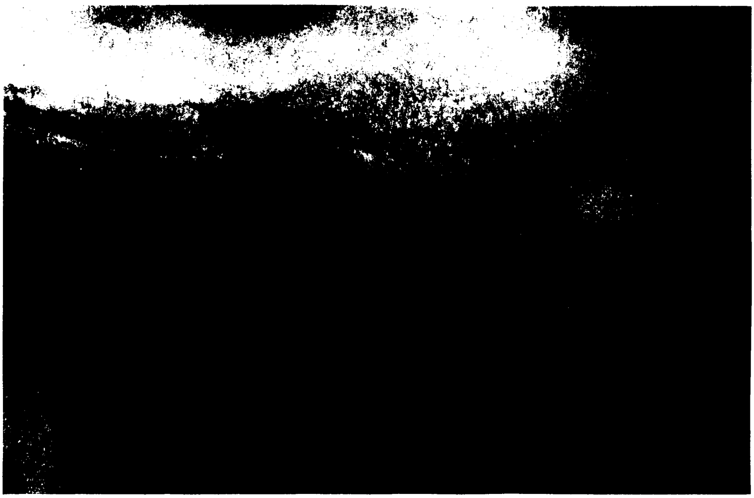


PLATE 2.

1

2

PLATE 3.



1

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PLATE 4.

NEW ARCHIPELAGIC MEMBRACIDÆ

By W. D. Funkhouser

Of the University of Kentucky, Lexington

TWO PLATES

Through the courtesy of Mr. R. C. McGregor, of the Philippine Bureau of Science, the writer has been permitted to examine from time to time a considerable number of specimens of Membracidæ from the Philippine Islands. From this material and from specimens which have been received from other parts of the Archipelago, the following new species may be described:

PYRGONOTA SINUATA sp. nov. Plate 1, fig. 1.

Large, brown, pubescent, punctate; pronotal horn long, heavy, sinuate, ridged, bifurcate at tip; posterior process long, slender, sinuate, without lateral carina, extending to internal angle of tegmina; tegmina brown, opaque, with small hyaline spot just before internal angle, basal and costal margin finely punctate; sides of thorax densely white tomentose; legs entirely lemon yellow.

Head obovate, longer than broad, roughly sculptured, finely punctate, sparingly pubescent, with long silky hairs which are white on median line and on clypeus; base strongly sinuate; eyes large, mottled brown and yellow; ocelli large, yellow, twice as far from each other as from the eyes and situated about on a line drawn through centers of eyes; clypeus broad, flat, extending for half its length below lateral margins of genæ and continuing the outline of the genæ, tip rounded and pilose.

Pronotum brown, coarsely punctate, sparingly pubescent with coarse, white hairs; humeral angles weak, not prominent; median carina percurrent; pronotal horns heavy, sinuate, longer than the rest of the body, extending forward and upward, lateral surfaces irregularly carinate, tip bifurcate with each prong again bifurcate; posterior process long, slender, sinuate, lateral areas not carinate, extending just to internal angles of tegmina, tip acute; scutellum very little exposed; inferior lateral margins of thorax toothed.

Tegmina opaque, brown, narrow, pointed; basal and costal areas finely punctate; veins heavy and not pilose; small hyaline spot at inner margin just before internal angle.

Sides of thorax and lateral bases of pronotum densely white tomentose; undersurface of abdomen brown with white pubescence.

Coxæ, trochanters, femora, tibiæ, and tarsi uniformly lemon. yellow; claws brown; first two pairs of tibiæ flattened.

Length from front of head to tips of tegmina, 9.5 millimeters; length of pronotal horn from humeral angle to tip, 12; width between humeral angles, 2.5.

Type, female.

Type locality, Ripang, northern Luzon, Philippine Islands.

Described from a single specimen secured from Staudinger-Bang-Haas and now in the author's collection.

HYPSAUCHENIA RECURVA sp. nov. Plate 1, fig. 2.

Small, brown, with yellow markings, punctate not pubescent; pronotal horn strongly recurved, bifurcate at tip, prongs flattened; posterior process heavy, a high conical elevation on dorsal margin; tegmina opaque, brown with a hyaline fascia at internal angle; area between pronotal horn and dorsal protuberance yellow; legs yellow-brown.

Head subtriangular, longer than broad, roughly sculptured, finely punctate, not pubescent, brown; base arcuately sinuate; eyes large, dark brown; ocelli large, elevated, yellowish, more than twice as far from each other as from the eyes and situated above a line drawn through centers of eyes; clypeus twice as long as wide, extending for two-thirds its length below inferior margins of genæ, tip rounded and blunt.

Pronotum brown with yellow carinæ, punctate, not pubescent; humeral angles rounded, blunt; median carina percurrent; a sharp yellow carina on each side median line on pronotum extending from above eyes to base of pronotal horn; pronotal horn long, slender, strongly curved backwards, suddenly concave before tip, tip bifurcate, the prongs flattened dorsoventrally, reaching to a point above the base of the posterior elevation; posterior process heavy, base yellow, bearing in middle of dorsal margin a large conical elevation, tip acute and reaching just to internal angle of tegmina; scutellum well exposed.

Tegmina opaque, brown; basal and lateral margins strongly and finely punctate; tip pointed; a large subrectangular hyaline spot at internal angle; veins not prominent, not pilose.

Sides of thorax and undersurface of body brown with irregular yellow fascia; inferior margins of thorax toothed; legs luteous-brown.

Length from front of head to tips of tegmina, 7 millimeters; width between humeral angles, 2.

Type, female.

Type locality, Roban, Java.

Described from two females in author's collection.

CENTROCHARES FOLIATUS sp. nov. Plate 1, fig. 3.

Large, black, very spiny, roughly punctate, not pubescent; pronotal horns slender with broadly foliaceous protuberance just before tip, tip acute and just reaching tips of tegmina; tegmina opaque, black, with internal apical area translucent brown; legs dark brown.

Head subtriangular, longer than wide, black, finely punctate, not pubescent, roughly sculptured, median depression deep between ocelli; base arcuate, feebly sinuate; eyes large, black, margined with brown; ocelli large, prominent, elevated, pearly, twice as far from each other as from the eyes and situated well above a line drawn through centers of eyes; clypeus twice as long as wide, extending for two-thirds its length below inferior margins of genæ, tip rounded and blunt.

Pronotum black, punctate, roughly spined, not pubescent; humeral angles large, prominent; metopidium about as wide as high, arcuate; median carina roughly percurrent; pronotal horns arising from behind and above humeral angles, extending outward and upward, slender for half their length, upper half swollen to form a broadly foliaceous tip, this tip subquadrate, roughly sculptured and carinate above, smooth below with a single carina, extremity suddenly acute; posterior process heavy, sinuate, the middle elevation consisting of a median dorsal and two lateral foliaceous protuberances, tip sharp and extending just to tips of tegmina; scutellum entirely exposed, bifid at tip.

Tegmina opaque, black, except at internal apical margin, which is translucent dark brown; basal and costal area strongly punctate; veins heavy, prominent, black; five apical cells.

Sides of thorax and undersurface of abdomen uniformly black; legs dark brown; all tibiæ foliaceous.

Length from front of head to tips of tegmina, 5.4 millimeters; width between tips of pronotal horns, 5.

Type, female.

Type locality, Mowong, West Borneo.

Described fron a single specimen. Type in author's collection.

CRYPTASPIDIA AURICULATA sp. nov. Plate 1, figs. 4 and 5.

Large, black, finely punctate, finely pubescent; humeral angles projected to form auricular horns; no suprahumeral horns; posterior process heavy, tectiform, acute, extending just beyond internal angles of tegmina; tegmina vinaceous, subhyaline, base black and punctate; undersurface of body black; legs dark brown.

Head subquadrate, wider than long, black, finely punctate, feebly pubescent; base arcuate; eyes large, brown; ocelli small, inconspicuous, pearly, farther from each other than from the eyes; clypeus twice as long as wide, extending for half its length below inferior margins of genæ, tip broad, truncate, pilose.

Pronotum black, finely punctate, finely pubescent; metopidium sloping, broader than high; humeral angles produced to form auricular projections, extending outward and slightly upward, about as long as half the distance between their bases, tips rounded; median carina faintly percurrent; posterior process heavy, tectiform, black, tip acute and reaching just beyond internal angle of tegmina; scutellum not exposed.

Tegmina smoky vinaceous hyaline; base coriaceous black and punctate; veins heavy, brown, not pilose.

Sides of thorax and undersurface of body black; legs very dark brown.

Length from front of head to tips of tegmina, 7 millimeters; width between tips of humeral extensions, 5.

Type, female.

Type locality, Ubi, Laguna Province, Luzon, Philippine Islands (*R. C. McGregor*), July, 1926.

This species suggests *Tricentrus auritus* Buckton, but the horns are extensions of the humeral angles and not supra humerals.

CRYPTASPIDIA LUSTRA sp. nov. Plate 1, fig. 6.

Large, black, shining, polished, faintly punctate at margin of pronotum, not pubescent; no suprahumerals; scutellum not exposed; posterior process reaching well beyond internal angles of tegmina; tegmina smoky hyaline with base black, a brown fascia across middle and a brown spot before apex; undersurface of body black; legs black marked with brown.

Head black, convex, twice as long as wide, longitudinally striate, not pubescent, not punctate, base regularly sinuate; eyes

large, gray, prominent; ocelli small, pearly, equidistant from each other and from the eyes and situated well above a line drawn through centers of eyes; clypeus obovate extending for half its length below inferior margins of clypeus, tip rounded and feebly pilose.

Pronotum black, shining, on metopidium and dorsum, faintly punctate at lateral margins, not pubescent; humeral angles large, prominent; metopidium sloping, broader than high; posterior process heavy, tricarinate, acute, extending well beyond internal angles of tegmina but not reaching tip of abdomen.

Tegmina smoky hyaline; base black, coriaceous and punctate; a broad brown fascia across center of tegmen and a brown spot on external margin before apex; veins brown; five apical and two discoidal areas.

Sides of thorax and undersurface of body black; femora black; tibiæ black at base and then shining brown for apical two-thirds; tarsi brown.

Length from front of head to tips of tegmina, 6.6 millimeters; width between tips of humeral angles, 3.5.

Type, female.

Type locality, Ripang, northern Luzon, Philippine Islands.

Described from a single specimen. Type in author's collection.

OTINOTOIDES PUBESCENS sp. nov. Plate 1, fig. 7.

Small, brown, punctate, densely pubescent with closely matted white hairs; suprahumeral horns heavy, black, extending outward and slightly upward; posterior process long, heavy, decurved, reaching almost to tips of tegmina; tegmina hyaline, base brown and punctate, veins strongly pubescent; sides of thorax white, tomentose; legs brown.

Head wider than long, light brown, densely pubescent; base arcuate, roughly sinuate; eyes large, yellowish; ocelli large, yellow, prominent, farther from each other than from the eyes and situated about on a line drawn through centers of eyes; clypeus as wide as long, trilobed, projecting for half its length below inferior margins of genæ, tip pointed.

Pronotum light brown, densely pubescent; metopidium as broad as high, nearly straight above head; humeral angles large, prominent; median carina very strongly percurrent; suprahumeral horns large, flattened dorsoventrally, about as long as the distance between their bases, projecting outward and very slightly upward, upper surfaces carinate; posterior process long,

heavy, decurved, base weakly laterally carinate, tip extending almost to tips of tegmina; scutellum strongly exposed, densely tomentose.

Tegmina hyaline; base and costal margin coriaceous, punctate, and densely pubescent; veins strong and strongly pubescent; five apical and two discoidal cells.

Sides of thorax entirely white tomentose; undersurface of abdomen densely pubescent; legs light brown; hind trochanters unarmed.

Length from front of head to tips of tegmina, 5.6 millimeters; width between tips of suprahumeral horns, 3.8.

Type, female.

Type locality, Amboina.

Described from a single specimen. Type in author's collection

MAGUVA NIGRA sp. nov. Plate 1, fig. 8.

Large, black, shining, punctate, not pubescent; suprahumeral horns long, slender, curved, sharp; posterior process sinuate with heavy conical elevation on basal dorsal margins; tegmina black with three hyaline fasciæ; undersurface black; legs dark brown.

Head much broader than long, convex, black, punctate, not pubescent; base irregularly arcuate; eyes large, black; ocelli small, amber-colored, not conspicuous, farther from each other than from the eyes and situated about on a line drawn through centers of eyes; clypeus twice as wide as long, strongly trilobed, projecting for half its length below inferior margins of genæ.

Prothorax black, shining, punctate, not pubescent; metopidium about as broad as high, sloping; humeral angles large, prominent, extending laterad farther than the eyes; median carina faintly percurrent; suprahumeral horns about as long as the distance between their bases, slender, curved, sharp, projecting upward and outward and curving slightly downward; posterior process sinuate, a heavy conical elevation at base, tip reaching to a point about halfway between internal angle and tip of tegmina; scutellum well exposed.

Tegmina black, coriaceous, opaque and punctate at base and on costal margin; internal margin from base to internal angle black but not punctate; a subquadrangular hyaline spot in middle of tegmen, separated by a black band from a transverse hyaline area behind it and this again separated by a narrow black band from a third hyaline area just before the tip; veins strong and black, not pilose; five apical and three discoidal areas.

Sides of thorax and undersurface of body black, lightly tomentose; legs dark brown.

Length from front of head to tips of tegmina, 6 millimeters; width between tips of suprahumeral horns, 4.

Type, female.

Type locality, Meranke, Dutch New Guinea.

Described from two females from the same locality. Type and paratype in author's collection.

EBHUL ELEGANS sp. nov. Plate 1, fig. 9.

Large, shining, brown, punctate, not pubescent; carinate on median dorsal line above humeral angles; no suprahumerals nor lateral carinæ; posterior process elevated above scutellum, then weakly sinuate, extending just to internal angles of tegmina; tegmina opaque, shining brown with hyaline spot before apex; sides of thorax strongly toothed; undersurface and legs brown.

Head longer than broad, strongly declivous, brown, punctate, not pubescent, roughly sculptured; base arcuate with a small nodule on each side median line; eyes large, light brown; ocelli small, brown, elevated, located very close to lateral margins, very much farther from each other than from the eyes and situated well above a line drawn through centers of eyes; clypeus longer than wide, extending for two-thirds its length below inferior margin of genæ, tip truncate.

Pronotum shining brown, finely punctate, not pubescent; metopidium broader than high, sloping; humeral angles strong, prominent; median carina strongly percurrent, produced to form a low crest on median dorsal line; no suprahumerals nor lateral carina above humeral angles; posterior process slightly elevated at base above scutellum, then weakly sinuate to tip which extends just to internal angles of tegmina; scutellum entirely exposed, longer than wide, bifid at tip.

Tegmina opaque, shining brown, punctate of basal and costal margins, a broad hyaline spot near external margin before the tip, this hyaline area crossed by two brown veins.

Sides of thorax produced to form two strong teeth on each side; legs and undersurface of body shining brown.

Length from front of head to tips of tegmina, 6 millimeters; width between tips of humeral angles, 2.5.

Type, female.

Type locality, Manorg, West Borneo.

Described from a single specimen. Type in author's collection.

TRICENTRUS PORRECTUS sp. nov. Plate 1, fig. 10.

Small, brown, punctate, pubescent; suprahumeral horns porrect, extending upward and forward; posterior process sharply carinate, acute, reaching just beyond internal angles of tegmina; tegmina hyaline, base brown and punctate, veins nodulate, a brown spot at apex; undersurface of body black; legs brown. This species seems to be very close to *T. projectus* Distant.

Head black, finely punctate, densely pubescent, black in front and brown behind; humeral angles weak, rounded; suprahumeral horns projecting upward, forward, and slightly outward, about as long as twice the distance between their bases, not extending laterad as far as the humeral angles, sharply anteriorly and posteriorly carinate, laterally compressed, tips rounded as seen from the side; scutellum broadly exposed, black at base and brown at tip, densely pilose. Posterior process strongly carinate above, tip acute and extending just beyond internal angles of tegmina.

Tegmina wrinkled, hyaline; base brown, opaque, and punctate; apical external margin narrowly brown; veins brown and strongly nodulate; five apical and two discoidal areas.

Sides of thorax black and pilose; undersurface of body black; trochanters black; femora black with brown tips; tibiæ and tarsi luteus.

Length from front of head to tips of tegmina, 1.7 millimeters; width between tips of suprahumerals, 1.7.

Type, male.

Type locality, Davao, Mindanao, Philippine Islands (*Francisco Rivera*), March, 1927.

Described from a single specimen. Type in author's collection.

TRICENTRUS FORTICORNIS sp. nov. Plate 1, fig. 11; Plate 2, fig. 12.

Large, black, punctate, pubescent; suprahumerals strong, heavy, sharp, extending upward and outward; posterior process slender, sharp, extending beyond internal angles of tegmina; tegmina bronze-hyaline, with outer margins darker; large white spot on abdomen shining through base of tegmina; undersurface black; legs brown.

Head subquadrate, black, finely punctate; densely pubescent with long golden hairs; base regularly arcuate; eyes large, brown; ocelli large, brown, equidistant from each other and from the eyes and situated slightly above a line drawn through centers of eyes; clypeus longer than wide, extending for more than half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum black, roughly punctate, pubescent with long golden hairs; humeral angles strong, prominent, blunt; median carina strongly percurrent; metopidium convex, about as wide as high; suprahumeral horns strong, heavy, extending outward and upward with tips curving backward, tricarinate, somewhat compressed dorsoventrally, more than twice as long as the distance between their bases, upper surface ridged at tip, tips acute; posterior process long, slender, tricarinate, acute, tip extending beyond internal angles of tegmina and just about reaching end of abdomen; scutellum well exposed.

Tegmina bronze-hyaline; base black, opaque, and punctate; external margin from base to tip dark brown; large white spot on abdomen shining through tegmen just behind opaque area; five apical and two discoidal cells.

Sides of thorax black and pubsecent; undersurface of body black; legs ferruginous brown.

Length from front of head to tips of tegmina, 7.2 millimeters; width between tips of suprahumerals, 4.4.

Type, male.

Described from a pair from Imugan, Nueva Vizcaya Province, Luzon, and a pair from Trinidad, northern Luzon, Philippine Islands, and one female labeled only "Philippine Islands." Collector, E. H. Taylor.

Type and two paratypes in author's collection; allotype and one paratype in collection of Philippine Bureau of Science.

TRICENTRUS BAKERI sp. nov. Plate 1, fig. 13; Plate 2, fig. 14.

Small, black, pubescent, punctate, suprahumerals projecting outward and slightly upward; posterior process reaching just beyond internal angles of tegmina; tegmina bronze-hyaline with bases black; undersurface black; legs dark brown; no tomentose patches.

Head subquadrate, finely punctate, densely pubescent; base feebly arcuate and sinuate; eyes light brown; ocelli pearly, slightly elevated, equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; clypeus longer than wide, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum black, finely punctate, densely pubescent with short golden hairs; metopidium wider than high, nearly straight; humeral angles blunt, prominent, triangular; median carina very faintly percurrent; suprahumeral horns heavy, tricarinate, extending outward and upward, about as long as the distance be-

tween their bases, tips sharp and recurved, compressed dorsoventrally, upper surface weakly carinate; posterior process heavy, carinate, acute, extending just beyond internal angles of tegmina; scutellum broadly exposed at sides.

Tegmina bronze-hyaline, wrinkled; base black, opaque, and punctate; five apical and two discoidal cells.

Sides of thorax black and pubescent; undersurface of body black; legs dark brown.

Length from front of head to tips of tegmina, 5.8 millimeters; width between tips of suprahumerals, 3.5.

Type, female.

Type locality, Sandakan, Borneo (*C. F. Baker*).

Described from four females and two males all from the same locality. Type, allotype, and three paratypes in author's collection; one paratype in collection of Philippine Bureau of Science.

TRICENTRUS ATTENUICORNIS sp. nov. Plate 1, fig. 15; Plate 2, fig. 16.

Golden brown, punctate, pubescent, suprahumeral horns short, very slender and sharp, extending outward and upward; posterior process long, carinate, sinuate, sharp, extending well beyond internal angles of tegmina; tegmina smoky hyaline, wrinkled, narrowly brown at base; undersurface and legs brown.

Head subquadrate, brown, finely punctate, densely pubescent; base feebly arcuate and sinuate; eyes large, light brown; ocelli large, amber-colored, equidistant from each other and from the eyes and situated slightly above a line drawn through centers of eyes; clypeus longer than wide, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum golden brown, finely punctate, densely pubescent; humeral angles large, prominent, triangular; metopidium broader than high, convex; suprahumeral horns short, slender, sharp, not as long as the distance between their bases, extending outward, upward, and backward, slightly compressed dorsoventrally, carinate above, tips acuminate; posterior process sharply carinate, heavy at base, slender for apical half, weakly sinuate, tip acuminate, tricarinate, reaching well beyond internal angles of tegmina, scutellum well exposed.

Tegmina smoky-hyaline, wrinkled; base narrowly brown, opaque and punctate; external margin faintly clouded with brown near apex; veins strong and brown; five apical and two discoidal cells.

Sides of prothorax dark brown, densely pubescent; undersurface dark brown; legs light brown.

Length from front of head to tips of tegmina, 6 millimeters; width between tips of suprahumerals, 3.6.

Type, female.

Type locality, Sandakan, Borneo (*C. F. Baker*).

Described from two females. Type and paratype in author's collection.

TRICENTRUS ALBESCENS sp. nov. Plate 1, fig. 17; Plate 2, fig. 18.

The single specimen described below, bearing Baker's duplicate No. 9826, has been standing for several years in our collection under the label *T. allebens* Distant and was so reported to Professor Baker. We have always been suspicious, however, of our determination and recently sent the specimen to Mr. W. E. China, of the British Museum, who kindly compared it with the type and reports that it is not Distant's species. We are therefore describing it as new. The writer is not aware at this time of the location of all of Baker's material, but his specimens bearing the above number should be referred to this species. This is a small black form with strongly recurved suprahumerals and a large white tomentose spot in the sides of the prothorax.

Head subquadrate, black, finely punctate, densely pubescent; base feebly sinuate; eyes brown; ocelli conspicuous, brown, farther from each other than from the eyes and situated above a line drawn through centers of eyes; clypeus twice as long as wide, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum black, finely punctate, finally and densely pubescent; metopidium broader than high, a glabrous spot above each eye; median carina weakly percurrent; humeral angles prominent, sharp; suprahumeral horns heavy, curved, extending outward and upward and curving backward, about as long as the distance between their bases, compressed dorsoventrally, tips acute, carinate above; posterior process straight; tricarinate, reaching beyond the internal angles of the tegmina; scutellum broadly exposed.

Tegmina hyaline, wrinkled, base broadly black, opaque, punctate, and pubescent; external margin from base to tip dark brown; five apical and two discoidal cells.

Sides of thorax densely white tomentose; undersurface of body black; femora dark brown; tibiæ and tarsi ferruginous.

Length from front of head to tips of tegmina, 4.6 millimeters; width between tips of suprahumerals, 3.

Type, female.

Type locality, Sandakan, Borneo (*C. F. Baker*).

Described from a single specimen. Type in author's collection.

TRICENTRUS FULGIDUS sp. nov. Plate 2, figs. 19 and 20.

Brown, shining, polished, not punctate, not pubescent; eyes brilliant red; shining white spot showing through bases of tegmina; suprahumerals short, blunt, extending directly outward; posterior process extending beyond internal angles of tegmina; undersurface brown.

Head subquadrate, broader than long, brown, shining, not punctate, not pubescent; base nearly straight; eyes bright red; ocelli pearly, inconspicuous, farther from each other than from the eyes and situated above a line drawn through centers of eyes; clypeus extending for half its length below inferior margin of genæ, tip rounded.

Pronotum dark brown, smooth, polished, not punctate, not pubescent; metopidium broader than high; humeral angles weak, blunt; median carina obsolete over metopidium; suprahumeral horns short, blunt, extending directly outward, not as long as one-fourth the distance between their bases; scutellum well exposed; posterior process very heavy at base, slender for posterior half, tip acuminate and extending well beyond internal angles of tegmina, almost reaching tip of abdomen.

Tegmina smoky, hyaline; base dark brown, opaque, and punctate; a broad white spot showing through tegmina just behind opaque area; veins very strong, brown; five apical and two discoidal areas.

Sides of thorax and undersurface of abdomen dark brown, almost black, very faintly pubescent; legs uniformly brown.

Length from front of head to tips of tegmina, 5.7 millimeters; width between tips of suprahumeral horns, 3.3.

Type, female.

Type locality, Pontianak, Borneo.

Described from a single specimen. Type in author's collection.

TRICENTRUS PAPUAENSIS sp. nov. Plate 2, figs. 21 and 22.

Small, black, punctate, pubescent; suprahumerals short, sharp, extending outward and backward; posterior process heavy, tricarinate, sharp, reaching beyond internal angles of tegmina; tegmina hyaline with base black; undersurface of body black; legs ferruginous brown.

Head subquadrate, wider than long, black, finely punctate, densely pubescent; base arcuate; eyes large, brown; ocelli large

but inconspicuous, translucent white, equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; clypeus longer than wide, deflexed, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum black, finely punctate, densely pubescent, with very short hairs; metopidium broader than high, sloping; median carina faintly percurrent; humeral angles weak, triangular, blunt; suprahumeral horns short, sharp, almost as long as half the distance between their bases, extending almost directly outward and curving strongly backward; scutellum widely exposed; posterior process heavy, tricarinate, base thick, apex attenuate, tip sharp and extending well beyond internal angles of tegmina, just about reaching tip of abdomen.

Tegmina hyaline, wrinkled; base black, opaque, and punctate; veins heavy, yellowish; five apical and two discoidal areas.

Sides of thorax and undersurface of abdomen black and pubescent; femora brown with apical ends ferruginous; tibiæ, tarsi, and claws ferruginous.

Length from front of head to tips of tegmina, 5.2 millimeters; width between tips of suprahumeral horns, 3.

Type, male.

Type locality, Laloki, Papua.

Described from a single specimen. Type in author's collection. We sent this specimen to Mr. W. E. China, of the British Museum, for comparison with the type of Walker's *T. congestus*, which it seemed to resemble, and he reported it as "near" this species but not identical.

TRICENTRUS FERRUGINOSUS sp. nov. Plate 2, figs. 23 and 24.

Large, ferruginous, punctate, pubescent; suprahumeral horns long, sharp, extending outward and upward, posterior process slightly curved, sharp, extending beyond internal angles of tegmina; tegmina fuscous-hyaline, wrinkled, base ferrunginous; undersurface and legs ferruginous.

Head wider than long, ferruginous, finely punctate, densely pubescent; base arcuate and slightly sinuate; eyes large, ferruginous; ocelli small, ferruginous, equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; clypeus longer than wide, deflexed, extending for half its length below inferior margins of genæ; tip rounded and pilose.

Pronotum ferruginous, finely punctate, densely pubescent; metopidium wider than high, sloping; median carina percurrent; humeral angles heavy, triangular, blunt; suprahumeral horns about as long as the distance between their bases, extending outward and upward, upper surface carinate, tips sharp; scutellum well exposed; posterior process long, slender, slightly curving upward, tricarinate, tip sharp and dark brown, extending beyond internal angles of tegmina, but not reaching tip of abdomen.

Tegmina fuscous-hyaline, much wrinkled; base ferruginous opaque and punctate; veins heavy and brown; five apical and two discoidal areas.

Sides of thorax ferruginous and pubescent; abdomen dark ferruginous; legs uniformly ferruginous.

Length from front of head to tips of tegmina, 6.5 millimeters; width between tips of suprahumeral horns, 4.6.

Type, female.

Type locality, Penang Island (*C. F. Baker*).

Described from a single specimen. Type in author's collection.

TRICENTRUS ALTIDORSUS sp. nov. Plate 2, figs. 25 and 26.

Small, brown, punctate, pubescent, suprahumerals broad and rounded; posterior process distinctly elevated; tegmina hyaline with brown bases; undersurface dark brown; legs brown.

Head subquadrangular, broader than long, dark brown, finely punctate, densely pubescent, convex; base regularly arcuate; eyes light brown; ocelli large, light yellow-brown, translucent, equidistant from each other and from the eyes and situated on a line drawn through centers of eyes; clypeus about as broad as long, extending for half its length below inferior margins of genæ, pilose, tip rounded.

Pronotum golden brown, finely punctate, densely pubescent; metopidium as broad as high, convex, darker above each eye; humeral angles triangular, prominent; suprahumeral horns half as long as the distance between their bases, stout, blunt, extending upward and outward, flattened dorsoventrally, tips rounded; scutellum well exposed; posterior process heavy, short, blunt, carinate, the dorsal margin strongly elevated, tip extending just beyond internal angles of tegmina.

Tegmina wrinkled hyaline; base coriaceous brown and punctate; tip pointed; veins indistinct; five apical and two discoidal areas.

Undersurface of body dark brown; legs golden brown; tarsi luteus brown.

Length from front of head to tips of tegmina, 4 millimeters; width between tips of suprahumeral horns, 2.8.

Type, female.

Type locality, Penang Island (*C. F. Baker*).

Described from a single specimen now in author's collection.

TRICENTRUS NIGROFRONTIS sp. nov. Plate 2, figs. 27 and 28.

Jet black with brown tegmina, punctate, pubescent; suprahumeral short, sharp, triangular, extending outward and upward; posterior process sharp, extending just to internal angles of tegmina; tegmina brown and subcoriaceous with bases black; undersurface black; legs dark brown.

Head black, punctate, pubescent; base sinuate and arcuate; eyes dark brown; ocelli amber-colored, translucent, conspicuous, equidistant from each other and from the eyes and situated about on a line drawn through center of eyes; clypeus deflexed, longer than broad, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum black, finely punctate, sparingly pubescent; metopidium convex, broader than high; median carina percurrent; humeral angles large, prominent, triangular; suprahumeral horns as long as half the distance between their bases, triquerate, sharp, extending outward and very slightly upward; scutellum well exposed; posterior process strong, carinate, sharp, extending just to internal angles of tegmina; dorsal margin slightly arcuate.

Tegmina brown, wrinkled, translucent, somewhat coriaceous; base opaque, black, and punctate; veins prominent, brown; five apical and two discoidal cells.

Undersurface of body black; sides of thorax pubescent; legs very dark brown; tarsi ferruginous brown.

Length from front of head to tips of tegmina, 5.6 millimeters; width between tips of suprahumeral horns, 3.2.

Type, female.

Type locality, Penang Island (*C. F. Baker*).

Described from a single specimen. Type in author's collection.

TRICENTRUS SULUENSIS sp. nov. Plate 2, figs. 29 and 30.

Black, punctate, pubescent; tegmina smoky hyaline with bases black; suprahumerals short, sharp, extending upward and backward; posterior process straight, sharp, extending just beyond internal angles of tegmina; undersurface black; legs ferruginous.

Head subquadrangular, broader than high, black, punctate, densely pubescent with golden hairs; base arcuate, slightly sin-

uate; eyes brown; ocelli large, brown, conspicuous, equidistant from each other and from the eyes and situated above a line drawn through centers of eyes; clypeus feebly trilobed, extending for half its length below inferior margins of genæ, tip rounded, densely pilose.

Pronotum black, finely punctate, densely pubescent; metopidium lightly convex, broader than high, a black spot above each eye; median carina distinct behind horns, obsolete over metopidium; suprahumerals as long as the distance between their bases, extending outward, upward, and curving backward; humeral angles broad, heavy, blunt; scutellum well exposed; posterior process strong, straight, sharp, tricarinate, extending slightly beyond internal angles of tegmina, but not reaching tip of abdomen.

Tegmina smoky hyaline, wrinkled; base opaque, black, and punctate; veins strong, brown, and at apical costal region distinctly pilose; five apical and two discoidal cells; terminal limbus narrow.

Undersurface of body black; sides of thorax densely pubescent; legs ferruginous.

Length from front of head to tips of tegmina, 6.5 millimeters; width between tips of suprahumeral horns, 3.8.

Type, female.

Type locality, Tawitawi, Sulu, Philippine Islands.

Described from a single specimen. Type in author's collection.

TRICENTRUS BRUNNEICORNIS sp. nov. Plate 2, figs. 31 and 32.

Small, yellow with suprahumerals and end of posterior process dark brown; punctate, pubescent; suprahumerals long, sharp, extending outward and upward; posterior process extending just beyond internal angles of tegmina; undersurface brown; legs yellow-brown.

Head dark brown, deflexed, punctate, densely pubescent; base nearly straight; eyes yellow-brown; ocelli large, yellow, prominent, elevated, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; clypeus brown, pubescent, extending for half its length below inferior margins of genæ, tip rounded and pilose.

Pronotum dark yellow with a spot above each eye; most of the suprahumerals and the apical half of the posterior process dark brown; metopidium broader than high, convex; median carina faintly percurrent; humeral angles large, prominent, triangular; suprahumeral horns as long as the distance between

their bases, sharp, brown, flattened dorsoventrally, extending outward and upward and curving backward; posterior process slender, straight, acute, tricarinate, reaching just beyond internal angles of tegmina; scutellum well exposed.

Tegmina hyaline and somewhat wrinkled; base brown, opaque, and punctate; veins prominent and brown; terminal limbus broad; five apical and two discoidal cells.

Undersurface of body dark brown; femora luteus brown; tibiæ and tarsi luteus.

Length from front of head to tips of tegmina, 5.4 millimeters; width between tips of suprahumeral horns, 3.

Type, male.

Type locality, Basilan, Philippine Islands.

Described from a single specimen. Type in author's collection.

TRICENTRUS PUBESCENS sp. nov. Plate 2, figs. 33 and 34.

Large, brown, punctate, densely pubescent; suprahumerals short, sharp, extending upward and outward; posterior process slender, sharp, extending beyond internal angles of tegmina; tegmina hyaline with base brown; undersurface brown; legs ferruginous.

Head subquadrangular, wider than long, brown, punctate, pubescent; base arcuate, feebly sinuate; eyes brown; ocelli small, pearly, inconspicuous, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; clypeus longer than wide, extending for half its length below inferior margins of genæ.

Pronotum brown, punctate, pubescent; metopidium broader than high with a dark spot above each eye; median carina percurrent; humeral angles strong, prominent, triangular; suprahumeral horns slender, sharp, as long as the distance between their bases, extending outward, slightly upward, and curving backward, faintly carinate on upper surface; scutellum well exposed; posterior process slender, sharp, slightly decurved, tricarinate, extending well beyond internal angles of tegmina but not reaching tip of abdomen.

Tegmina wrinkled hyaline; base brown, opaque, and punctate; veins heavy and brown; apical limbus broad; five apical and two discoidal cells.

Undersurface of body dark brown; legs and tarsi ferruginous.

Length from front of head to tips of tegmina, 6.8 millimeters; width between tips of suprahumerals, 4.2.

Type, female.

Type locality, Catbalogan, Samar, Philippine Islands.

Described from a single specimen. Type in author's collection.

GARGARA ORNATA sp. nov.

Small, black, punctate, pubescent; posterior process sinuate, just reaching internal angles of tegmina; tegmina dark brown, decorated with many white spots; undersurface and legs black.

Head subovate, longer than wide, black, punctate, pubescent, convex; base weakly sinuate; eyes large, glassy; ocelli very small, transparent, inconspicuous, twice as far from each other as from the eyes and situated above a line drawn through centers of eyes; clypeus spatulate, extending for half its length below inferior margins of genæ, tip broadly rounded.

Pronotum black, finely punctate, finely pubescent; metopidium sloping, wider than high; median carina strong on posterior process but obsolete on metopidium; humeral angles large, prominent, triangular; no suprahumerals; scutellum broadly exposed at sides; posterior process short, sinuate, blunt, extending just to the internal angles of the tegmina.

Tegmina opaque, brown, thickly decorated with white spots; veins indistinct; five apical and two discoidal cells; tip rounded; apical limbus narrow.

Undersurface of body entirely black; legs and feet black.

Length from front of head to tips of tegmina, 2.8 millimeters; width between humeral angles, 1.6.

Type, male.

Type locality, Borneo.

Described from a single specimen. Type in author's collection.

GARGARA BRUNNEIDORSATA sp. nov.

Small, black, punctate, not pubescent; median dorsal area broadly brown; posterior process short, heavy, blunt, decurved, reaching just to internal angles of tegmina; tegmina with basal half hyaline and apical half broadly brown; undersurface black; legs brown.

Head subquadrangular, nearly twice as broad as high, convex, finely punctate, not pubescent; base sinuate; eyes brown; ocelli small, opaque white, prominent, twice as far from each other as from the eyes and situated well above a line drawn through centers of eyes; clypeus triangular, extending for one-fourth its length beyond inferior margins of genæ, tip broadly rounded, slightly pubescent.

Pronotum black, finely punctate, not pubescent; median carina sharp on posterior process but not extending over metopidium;

median dorsal line broadly brown; metopidium sloping, wider than high; humeral angles prominent, blunt; posterior process short, blunt, decurved, extending just to internal angles of tegmina; scutellum narrowly exposed.

Tegmina with basal half hyaline and apical half opaque with large brown spot covering almost all of distal portion; veins indistinct; five apical and two discoidal cells; tip rounded; apical limbus narrow; costal marginal vein feebly punctate.

Undersurface of body black; femora dark brown except apices which are ferruginous; tibiæ light brown; tarsi luteus-brown.

Length from front of head to tips of tegmina, 3.6 millimeters; width between humeral angles, 1.8.

Type, female.

Type locality, Pekalongan, Java.

Described from a single specimen. Type in author's collection.

242525——9

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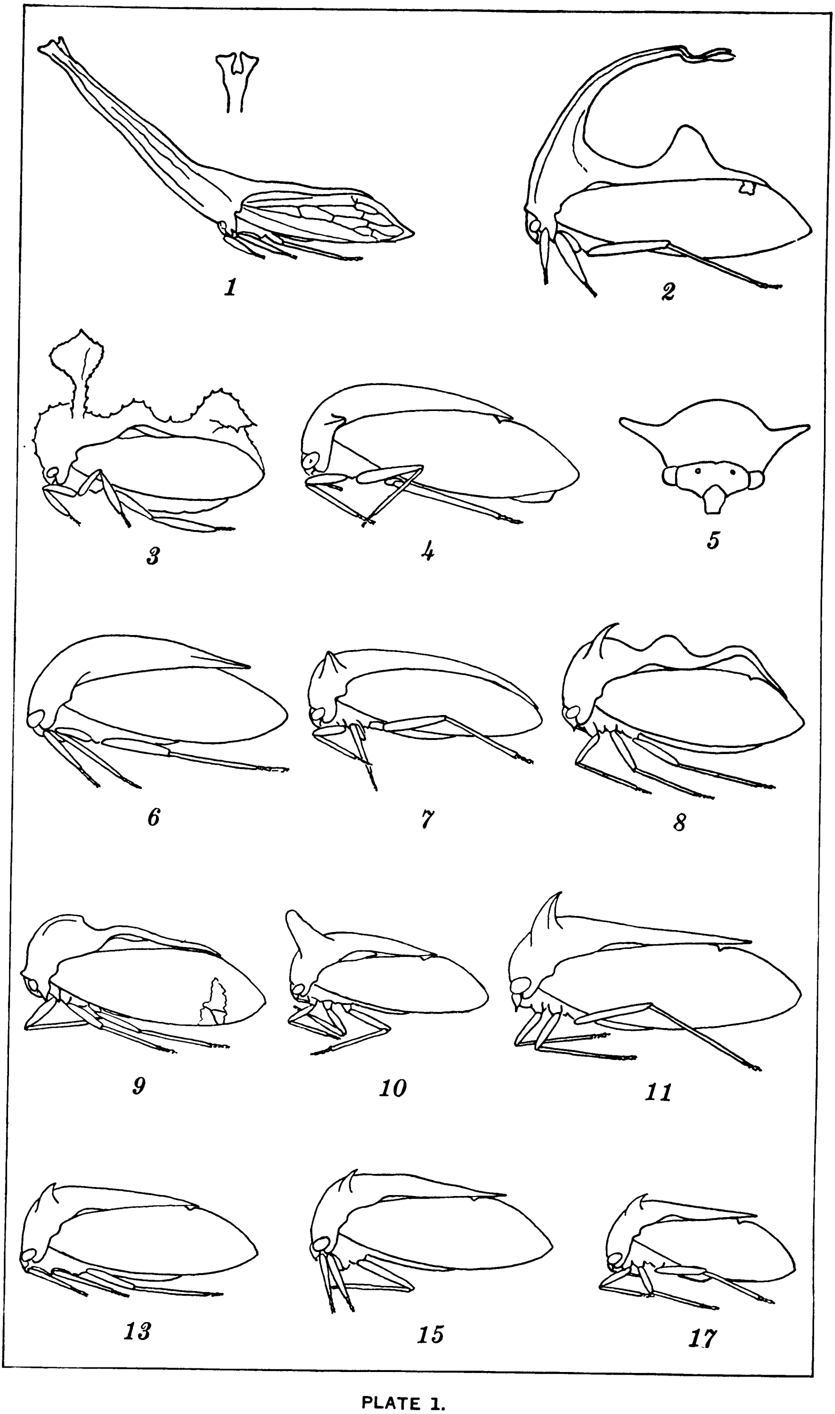
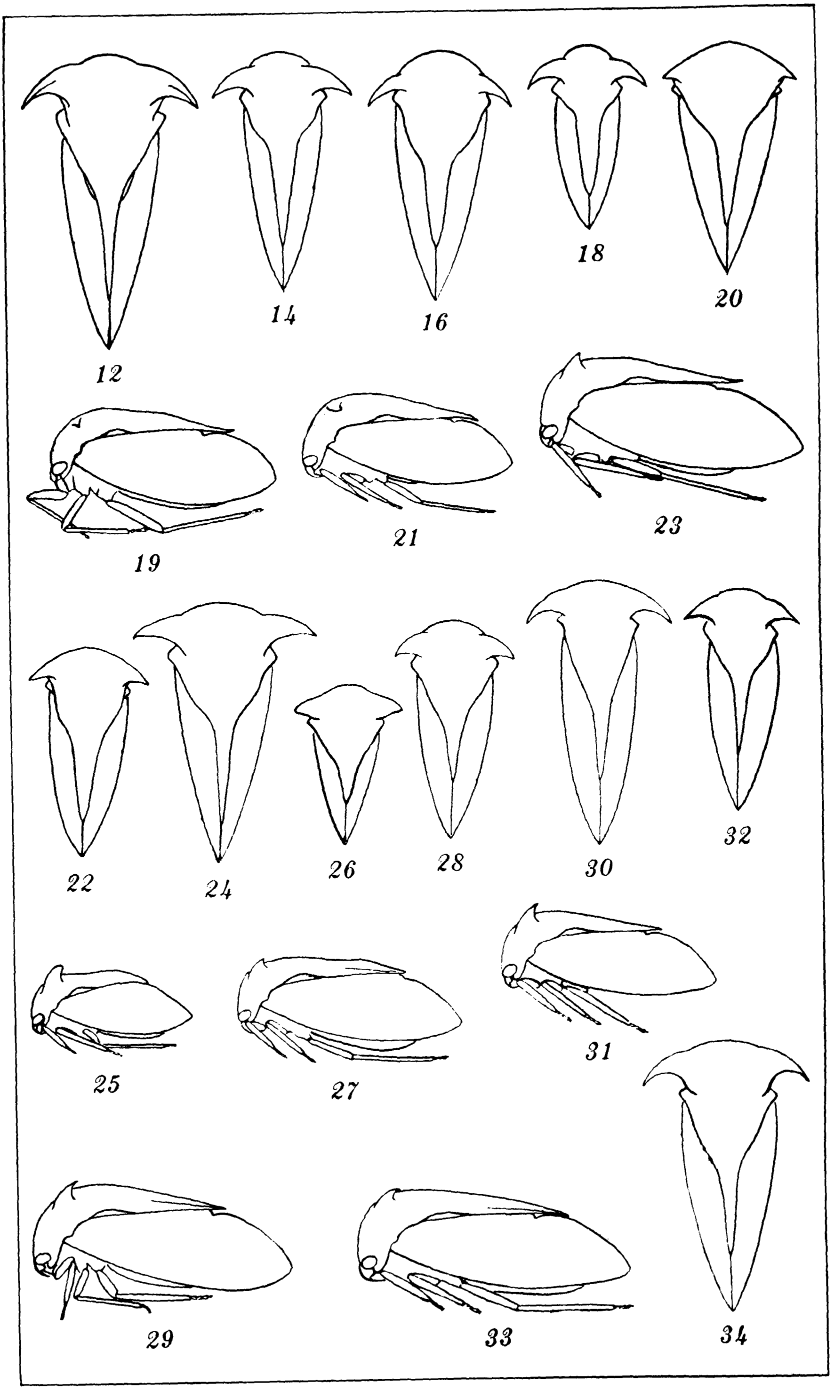


PLATE 1.



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The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

Yearly subscription, beginning with Volume XIV, 5 dollars United States currency. Single numbers, 50 cents each.

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Entered at the post office at Manila, P. I., as second-class matter.

VOL. 40, NO. 2 OCTOBER, 1929

THE PHILIPPINE JOURNAL OF SCIENCE

MANILA
BUREAU OF PRINTING
1929

245651

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science, Department of Agriculture and Natural Resources
Government of the Philippine Islands

Manuscript intended for publication should be sent to the editor. One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

Publications sent in exchange for the Philippine Journal of Science should be addressed: Library, Bureau of Science, Manila, P. I.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 40 OCTOBER, 1929 No. 2

PHILIPPINE ERICACEÆ, I: THE SPECIES OF RHODODENDRON

By HERBERT F. COPELAND

Of Sacramento Junior College, Sacramento, California

SIXTEEN PLATES

INTRODUCTION

The Philippine species of the large, widespread, and polymorphous genus *Rhododendron* are almost entirely confined to the mossy forest on ridges leading up to mountain peaks and on the peaks themselves. The mossy forest is an environment of high humidity, low illumination, and moderate temperature; the vegetation thrives under conditions of intense competition for space and light.

In isolation, here furnished by mountain tops, and under the pressure of competition, organisms show markedly a tendency to produce series of distinct forms, which, by some authors, are described as species. In the present genus this is particularly noticeable in *Rhododendron quadrasianum* and *R. vidalii* and in the circle of relationship of *R. clementis*.

The environment of the tropical mossy forest induces many plants to live as epiphytes. Thus most of the species in the group under discussion occur as epiphytes, but they are also capable of terrestrial life wherever they find space; some of them reach the size of small trees.

The flowers of several species are large, brightly colored, and extremely attractive. It was the hope of Stein, expressed in his description of *R. apoanum* and *R. kochii,* that both might

speedily be brought into cultivation. As far as is known, this has never been accomplished, either for these species or for any others occurring in the Philippines. Several related species from the Malay Peninsula and Archipelago are described in Curtis's Botanical Magazine as in cultivation under glass in England fifty or more years ago, and doubtless most or all of the Philippine species could thus be grown.

The mountain flora was unknown to Blanco and his predecessors. No Philippine *Rhododendron* was named before 1883, although at least four collections had been made. *Cuming 804*, collected on Mount Banahao in 1839, represents a form of *R. quadrasianum;* the exploration of Mount Banahao by Vidal yielded one more, which he identified as *R. javanicum,* but which we now know represents *R. kochii.* The ascent of Mount Apo by Koch and Schadenberg, in 1882, yielded two species that were incorrectly identified by Fernandez-Villar, in 1883, as *R. javanicum* and *R. jasminiflorum.* Stein named them respectively *R. apoanum* and *R. kochii,* apparently in Verhandlungen der schlesischen Gesellschaft für vaterländische Cultur for 1883; I have not seen this publication. In 1885 he gave full descriptions of both species in Gartenflora, with illustrations.

In 1886 Vidal, the ablest Spanish botanist in the Philippines, listed six species in his Revision de Plantas Vasculares Filipinas: *R. javanicum, R. kochii, R. apoanum,* and three new species, *R. quadrasianum, R. rosmarinifolium,* and *R. verticillatum.* In the following year Rolfe changed the name of the last species to *R. vidallii* (*R. verticillatum* Vidal, nom Low). Another I have here reduced. Vidal remains the authority for the name of the commonest Philippine species, *R. quadrasianum.*

The collections made by John Whitehead in 1896 were studied at the British Museum, and A. B. Rendle described *R. subsessile, R. whiteheadi,* and *R. lussoniense* as new; the last, however, is identical with *R. vidalii.* He also identified a specimen from Mount Halcon as *R. cuneifolium* Stapf, which was correct in the sense that in my opinion *R. cuneifolium* is indistinguishable as a species from *R. quadrasianum.*

Soon after the American occupation of the Islands, J. Perkins began to study the Philippine material in European herbaria, particularly in Berlin. In connection with her work, Warburg described the rare *R. schadenbergii* in 1905.

In the same year, in his third paper on new or noteworthy Philippine plants, Merrill enumerated the fourteen known spe-

cies, including the new *R. xanthopetalum*, *R. mindanaense*, *R. spectabile*, and *R. copelandi*, the first from the collections of Whitford on Mount Mariveles, the other three from the collections of Copeland on Mount Apo. He added *R. nortoniae* in 1906 and *R. clementis*, *R. curranii*, and *R. malindangense* in 1908; in the latter year he again reviewed the whole group and listed sixteen species. In 1925 he added *R. leytense*, and in 1926 the very distinct *R. taxifolium*.

Elmer's numerous and valuable collections have yielded no new species except *R. williamsii*, belatedly described below. His paper on the Ericaceæ of Mount Apo, published in 1910 in Leaflets of Philippine Botany, is valuable for the descriptions of plants in the field.

Millais's Rhododendrons, 1917 and 1924, was written from a horticultural point of view. The Philippine species are enumerated with little comment.

The *monograph of Azaleas*, by Wilson and Rehder, 1921, includes a discussion of the relationships of *R. subsessile*, the only Philippine representative of the group.

In the present paper three Philippine species are reduced and *R. cuneifolium* Stapf, of Mount Kina-Balu, in British North Borneo, is identified with *R. quadrasianum*. Five species are published for the first time, making a total of twenty-one. It is confidently expected, however, that further exploration will yield others.

For the present study I have had the use of the collections, Philippine and Indo-Malayan, in the herbarium of the Philippine Bureau of Science, the United States National Herbarium, and the herbarium of the University of California. In the lists of specimens given under each species, I have designated these herbaria, respectively, by the letters M, W, and C. It has been my task to review critically the definitions of the species and the identifications of all the specimens; and, this being completed, to attempt to determine the relationships of the Philippine species, both among themselves and with those of neighboring lands.

Rhododendron subsessile, in contrast to all the other species, is of northern ancestry and finds its nearest relatives in Formosa; it is the sole representative of its section in the Malayan region. The others find their closest relatives in Borneo, with allied species in Java, Sumatra, and New Guinea; it is probable that their ancestors came from India through the Malay Penin-

sula. Only one species is known to extend outside the Philippines, but as Borneo, Celebes, New Guinea, and Sumatra, as well as Mindanao and Palawan in the Philippine group, remain imperfectly explored, it is likely that the list will be increased as exploration progresses.

I have divided the section *Vireya,* to which most of the species belong, into subsections. In part this classification is tentative, but with possible modifications it is expected to prove useful throughout the Malay region.

The work has been carried out at the University of California, Berkeley, under the direction of Dean E. D. Merrill, to whom it is a pleasure to acknowledge a very comprehensive indebtedness.

Natural arrangement of the Philippine rhododendrons.

Subgenus *Eurhododendron* Endlicher.

[Section 1. *Leiorhodion* Rehder. Leaves glabrous. Not represented.]

Section 2. *Lepipherum* G. Don. Leaves more or less densely lepidote; ovary densely lepidote; margins of the bud-scales white-ciliate.

A. Leaves moderately lepidote beneath .... 1. *R. quadrasianum.*

B. Leaves densely lepidote beneath.

1. Leaves elliptic; filaments glabrous.................... 2. R. *apoanum.*

2. Leaves narrow-lanceolate, 9 to 15 cm long; filaments pubescent .... 3. *R. nortoniae.*

3. Leaves narrow-lanceolate, 5 to 10 cm long; filaments unknown. 4. *R. catanduanense.*

Section 3. *Vireya* Blume as genus. Leaves moderately lepidote; ovary pubescent, glabrous, or moderately lepidote. Bud-scales not white-ciliate except sometimes in subsection 1.

Subsection 1. *Malesia.* Ovary pubescent, filaments glabrous. A single species .... 5. *R. bagobonum.*

In the following subsections the filaments are pubescent; or, if they are glabrous, the ovary is without hairs.

Subsection 2. *Linearanthera.* Bud-scales acute or acuminate, with brown-fimbriate margins; corolla hairy within, hairy or lepidote without; ovary and filaments pubescent; anthers linear.

A. Leaves orbicular to narrowly elliptic.

1. Flowers white ....6. *R. vidalii.*

2. Flowers red ....7. *R. whiteheadi.*

B. Leaves linear ....8. *R. taxifolium.*

In the following subsections the bud-scales are rounded, with entire margins.

Subsection 3. *Solenovireya.* Bud-scales about 1 cm long; corolla narrowly tubular, usually lepidote without; filaments filiform, pubescent; ovary lepidote to pubescent, style filiform. A single species............................9. *R. copelandi.*

In the following subsections the bud-scales are larger; the corolla is funnelform or obconical, usually hairy within and glabrous without.

Subsection 4. *Euvireya.* Leaves herbaceous; filaments and ovary with or without hairs, in the Philippine species alike; anthers obovoid, often with minute appendages at the base.

A. Flowers white.
  1. Leaves rounded; corolla lepidote without; anthers appendaged ....12. *R. mindanaense.*
  2. Leaves acuminate; corolla glabrous without; anthers not appendaged.
    a. Filaments and ovary pubescent................10. *R. kochii.*
    b. Filaments and ovary glabrous..............11. *R. williamsii.*

B. Flowers yellow.
  1. Leaves acuminate; pistil about half as long as the stamens; anthers appendaged............13. *R. brachygynum.*
  2. Leaves acute or rounded; pistil about as long as the stamens.
    a. Anthers appendaged ....14. *R. loheri.*
    b. Anthers not appendaged..........................15. *R. leytense.*

Subsection 5. *Leiovireya.* Leaves leathery; corolla colored, glabrous without; ovary glabrous or moderately lepidote; filaments usually pubescent, anthers large, linear, without appendages.

A. Filaments pubescent.
  1. Disk crowned with abundant hairs.
    a. Ovary glabrous; flowers usually orange. 16. *R. clementis.*
    b. Ovary lepidote; flowers yellow....18. *R. xanthopetalum.*
  2. Disk crowned with very few hairs; flowers red. 17. *R. spectabile.*
  3. Disk strictly glabrous, flowers salmon pink........................ 19. *R. schadenbergii.*

B. Filaments, disk, and ovary strictly glabrous; flowers yellow ....20. *R. loboense.*

Subgenus *Anthodendron* Endlicher.

Section *Tsutsutsi* G. Don. No parts lepidote; foliage covered with flattened hairs; seeds not appendaged. A single species, flowers pink to purplish, small, stamens 10..21. *R. subsessile.*

Artificial key to the Philippine species of Rhododendron.

1. Lower surface of leaves, and bracts and ovary, brown-pubescent. 21. *R. subsessile.*
1. Leaves and bracts not brown pubescent.
  2. Ovary densely lepidote; margins of bud-scales white-ciliate.
    3. Leaves very densely lepidote beneath.
      4. Leaves elliptic to oval; terrestrial, filaments glabrous. 2. *R. apoanum.*
      4. Leaves narrowly lanceolate; epiphytes.
        5. Leaves 9 to 15 cm long; filaments pubescent....3. *R. nortoniae.*
        5. Leaves 5 to 10 cm long (flowers unknown)..4. *R. catanduanense.*
    3. Leaves sparsely lepidote beneath, small...........1. *R. quadrasianum.*

2. Ovary pubescent; margins of bud-scales not white-ciliate.
   3. Corolla slenderly tubular, white.....9. *R. copelandi.*
   3. Corolla not slenderly tubular.
      4. Flowers white.
         5. Leaves acuminate, 6 to 15 cm long; anthers ovate, without appendages .....10. *R. kochii.*
         5. Leaves rounded, 5 to 7 cm long; anthers ovate, with minute appendages .....12. *R. mindanaense.*
         5. Leaves obtuse, 2.5 to 5.5 cm long; anthers linear, without appendages .....6. *R. vidalii.*
         5. Leaves linear, 2 to 3.5 cm long; anthers linear, without appendages .....8. *R. taxifolium.*
      4. Flowers yellow.
         5. Pistil about half as long as the stamens; leaves herbaceous, acuminate, about 10 cm long, drying yellow. 13. *R. brachygynum.*
         5. Pistil about as long as the stamens; leaves obtuse, slightly fleshy, drying brown.
            6. Corolla membranous when dry, anthers not appendaged. 15. *R. leytense.*
            6. Corolla chartaceous when dry, anthers bearing minute basal appendages .....14. *R. loheri.*
      4. Flowers red.
         5. Corolla about 2.5 cm long, pubescent.....7. *R. whiteheadi.*
         5. Corolla about 1 cm long, glabrous.....5. *R. bagobonum.*
2. Ovary glabrous to moderately lepidote, margins of bud-scales not white-ciliate.
   3. Flowers white; leaves herbaceous, slightly acuminate; filaments, ovary, and disk glabrous.....11. *R. williamsii.*
   3. Flowers colored; leaves leathery, acute or rounded.
   4. Filaments, ovary, and disk glabrous; flowers yellow. 20. *R. loboense.*
   4. Filaments hairy.
      5. Ovary lepidote, disk bearing hairs; flowers yellow. 18. *R. xanthopetalum.*
      5. Ovary glabrous.
         6. Disk bearing hairs, slightly wider than the ovary; flowers usually orange.....16. *R. clementis.*
         6. Disk practically glabrous, much wider than the ovary; flowers red .....17. *R. spectabile.*
         6. Disk glabrous; flowers salmon-pink.....19. *R. schadenbergii.*

Subgenus EURHODODENDRON Endlcher

This is the main division of the genus, including the rhododendrons with the exception of the azaleas and a series of minor groups. The group can scarcely be defined by description. The present treatment of the group, as to limits and subdivisions, follows the work of Drude[1] and of Wilson.[2]

[1] In Engler and Prantl, Natürl. Pflanzenf. 4[1] (1897) 35–37.
[2] Journ. Arn. Arb. 5 (1924) 86.

Section LEPIPHERUM G. Don

Rhododendron Sect. I *Ponticum* and IV *Lepipherum* G. DON, Gen. Syst. 3 (1834) 843–845.

Rhododendron Sect. III *Eurhododendron* DC., Prodr. 7[2] (1839) 721–725.

Rhododendron Sect. *Osmothamnus* MAXIMOVICZ, Mém. Acad. Imp. Sci. St. Pétersb. VII 16[9] (1870) 15.

Rhododendron Ser. I *Eurhododendron* (in part), II *Graveolentes*, and III *Osmothamnus* HOOK. f., Gen. Pl. 2[2] (1876) 600–601.

Rhododendron Subg. I *Eurhododendron* Sect. 2 *Osmothamnus* DRUDE in Engler and Prantl Natürl. Pflanzenf. 4[1] (1897) 36–37.

Rhododendron Subg. I *Eurhododendron* Sect. 2 *Lepipherum* WILSON, Journ. Arn. Arb. 5 (1923) 84–107.

Leaves persistent, more or less clothed with lepidote glands; bud-scales with white-ciliate margins; stamens 10; ovary densely lepidote; seeds with short appendages (as compared with *Vireya*) or none.

This is the type section of the genus and includes *R. ferrugineum* Linnæus, of the Alps, the type species, as well as many species in the Himalayas and China. The Malayan species, including the Philippine, are perhaps somewhat distinct, and usually have been included in the section *Vireya*.

1. RHODODENDRON QUADRASIANUM Vidal.

Rhododendron quadrasianum VIDAL, Rev. Pl. Vasc. Filip. (1886) 170; ELMER in Leafl. Philip. Bot. 3 (1911) 1106; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 43; Philip. Journ. Sci. 1 (1906) Suppl. 111, 2 (1907) Bot. 292, 3 (1908) Bot. 382; Enum. Philip. Fl. Pl. 3 (1923) 224; MILLAIS, Rhodod. (1917) 233, 2d ser. (1924) 218.

Vidal's original description is as follows:

Fruticulus, rarius frutex; ramulis sub-angulatis, cum pulvinis foliorum dense notatis, cinereis vel junioribus brunneis. Folia sub-sessilia, obovata-oblonga aut lineare-oblonga, basi cuneata, apice rotundata vel sub-emarginata, longa 10–25 mm. lata 3–9 mm., coriacea, supra nitida, subtus ferruginea scrobi-culato-nigro-punctata. margine incrassata-revoluta. Gemmae floriferae squamis rotundatis, ciliatis. Calyx parvus, 5-dentatus vel sub-truncatus. Corol[l]a anguste campanulata, rubra, circ. 15 mm. longa; lobis 5, brevibus, rotundatis; ad lentem punctata. Stamina inclusa. Ovarium 5-lobatum, lepidotum, loculis 5. Fructus junior lobatus, rugosus, lepidotus.

819 Volcan Mayon, 1,700 m., Pr. Albay.—Cum. 804 Pr. Tayabas.

Los ejemplares que han servido para la description fueron recogidos por el Ayudante D. José Florencio Quadras. La planta de Cuming parece idéntica.

The original description may be amplified to read as follows:

Planta lignosa, aut epiphytum, aut frutex terrestris, aut arbor parva, foliis parvis, floribus parvis, rubris. Rami grisei, ra-

muli junioris graciles, minute striati, brunnei, lepidoti, leviter ad dense puberuli. Folia commutabilia, linearia ad oblanceolata vel obovata, fere sessilia, rotundata vel emarginata, coriacea, utrinque lepidota, vulgo uninervia, 5 ad plus quam 30 mm longa, 1 ad 10 mm lata, superficiebus superioribus quam inferioribus obscurioribus, nitidis, marginibus recurvis. Gemmae floriferae 5 ad 15 mm longae, bracteis suborbicularibus, apiculatis, bruneis, lepidotis, albo-ciliatis, exterioribus minoribus. Flores vulgo solitarii, interdum bini vel glomerati. Pedicelli graciles, 10 ad 20 mm longi, brunnei, lepidoti atque pubescentes, grado pubescentiae squamficationisque commutabilissimo. Calyx est discus minutus, lobis interdum manifestis. Corolla rubra, 8 ad 20 mm longa, campanulata ad tubulosa, leviter irregularis, extus lepidota atque pubescens, lobis suborbicularibus, rotundatis. Stamina tubo corollae aequantes, filamentis complanatis, omnino glabris, antheris subglobosis, poribus hiantibus. Pistillum tubo corollae aequale, ovario 2 mm longo, dense lepidoto, 5-loculare, stylo filiforme, stigmate minuto. Fructus flavus, fusiformis, 1 ad 2 cm longus, valvis in dehiscentia in medio superiore separantibus. Semina utrinque appendiculata, appendiculis incongruentibus, seminibus aequalibus.

Typus e Monte Mayon, Vidal 819; non vidi.

Habitat in montibus in omnibus Insulis Philippinis, atque in Borneo.

This is the commonest representative of the genus in the Philippines. It is exceedingly variable; on almost every mountain there is a distinct variety, but the varietal characters are inconstant. It is impossible to detect constant characters by which to distinguish *R. malindangense* and the Bornean *R. cuneifolium* Stapf from *R. quadrasianum*. Typical *R. rosmarinifolium* Vidal is distinct from typical *R. quadrasianum* but there exist several complete series of intergrades.

I propose the following definitions of subspecific groups and assignment of specimens:

A. Typical RHONDODENDRON QUADRASIANUM.

Frutex terrestris. Folia late oblanceolata, usque ad 30 mm longa, 13 mm lata. Gemmae usque ad 9 mm longae, bracteis puberulis, leviter lepidotis. Flores vulgo bini vel glomerati, pedicellis puberulentis, in fructu glabris, corolla anguste campanulata, circa 15 mm longa. Fructi glomerati, fere recti, vulgo minus quam 10 mm longi.

LUZON, Albay Province, Mount Mayon, *Bur. Sci. 6502 Robinson* (M, W) : Sorsogon Province, Mount Bagaua, *Bur. Sci. 23422 Ramos and Edaño* (M, W).

Without seeing type material, I take this large-leaved terrestrial form as typical of the species. The first specimen cited comes from the type locality, and its measurements agree very closely with those given in the original description.

B. Forma MARIVELESENSE forma nova.

Arbor parva (vulgo). Folia oblanceolata, usque ad 20 mm longa, 8 mm lata. Gemmae circa 5 mm longae, bracteis fere glabris. Flores vulgo solitarii, pedicellis puberulis, vix lepidotis, corolla tubulosa, circa 15 mm longa. Fructus circa 10 mm longi, robusti, paene recti.

LUZON, Bataan Province, Mount Mariveles, *Merrill 3215* (M, W; type of the form), *Leiberg 6302* (M), *Whitford 278, 1104* (M, W), *Merrill Decades 299* (M, C), *Elmer 6765* (M), *For. Bur. 2090 Borden* (M) : Rizal Province, *Loher 3764, 15098* (M, C) : Laguna Province, Mount Maquiling, *Loher 3764, 6188* (W), *For. Bur. 7703 Curran and Merritt* (M), *Baker s. n.* (M), *Elmer 17488* (M, W, C), *For. Bur. 28925 Sulit and Salvosa* (M) ; Mount San Cristobal, *Gates s. n.* (M) : Batangas Province, Mount Agas, *For. Bur. 7716 Curran and Merritt* (M). MINDORO, Mount Halcon, *For. Bur. 4408 Merritt* (M), *Merrill 6158* (M, W). LEYTE, *Wenzel 930* (M).

This is the commonest form, recognizable by the pedicels, which are hairy and very slightly lepidote, the small buds, etc. The specimens from Mount Halcon are not typical; they represent a transition to the next.

C. Forma HALCONENSE forma nova.

R. cuneifolium RENDLE in Journ. Bot. 34 (1896) 355; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 43, non Stapf.

R. quadrasianum var. *intermedium* MERRILL in Philip. Journ. Sci. 3 (1908) Bot. 382; Enum. Philip. Fl. Pl. 3 (1923) 244, in part.

Suffrutex terrestris, foliis cuneatis, circa 12 mm losgis, 3 mm latis. Gemmanae circa 5 mm longae, bracteis fere glabris; pedicelli sparsim lepidoti et pubescentes.

MINDORO, Mount Halcon, *Merrill 5736* (M, W; type of the form), *Whitehead,* 1896 (M. fragm. ex Herb. Mus. Brit.).

Occurs only at high altitudes. Distinguished from most of the other forms by the small and narrowly but definitely cuneate leaves.

D. Forma NEGROSENSE forma nova.

Aut arbores, aut frutices, aut epiphyta. Folia oblanceolata, emarginata, 15 ad 25 mm longa, circa 8 mm lata. Gemmae plus quam 5 mm longae bracteis sparsim pubescentibus. Flores saepe bini, pedicellis sparsim lepidotis et pubescentibus, corollis campanulatis, circa 13 mm longis. Fructus rectus vel arcuatus, robustus, circa 15 mm longus.

NEGROS, Canlaon Volcano, *Banks* (M), *Merrill 247* (M, W; type of the form); Mount Mapara, *For. Bur. 13616 Curran and Merritt* (M, W); Cuernos Mountains, *Elmer 9738* (M, W).

E. Var. MALINDANGENSE (Merrill) comb. nov.

Rhododendron malindangense MERRILL in Philip. Journ. Sci. **3** (1908) Bot. 256, 381; Enum. Philip. Fl. Pl. **3** (1923) 244; MILLAIS, Rhodod. (1917) 206, 2d ser. (1924) 183.

Merrill's original description is as follows:

Arbor parva, ramis glabris, griseis, ramulis junioribus brunneis, puberulis; foliis coriaceis, pallidis, oblongo-ovatis, apice rotundatis vel emarginatis, basi cuneatis, utrinque squamulis glandulosis paucis notatis; bracteis ovatis, coriaceis, acutis, margine breviter ciliato excepto glabris; floribus solitariis, 2 cm longis, tubo cylindraceo; staminibus 10, inaequalibus, glabris; ovario 5-loculare, dense lepidoto.

A small tree about 7 m high, the branches terete, grayish, glabrous, the younger branches reddish-brown, puberulent. Leaves coriaceous, pale, oblong-ovate, the apex rounded or emarginate, the base cuneate, alternate or subverticillately arranged at the apices of the branchlets, glabrous except for the few scattered glandular scales on both surfaces, 1.5 to 3 cm long, 7 to 10 mm wide; nerves nearly obsolete; petioles 2 to 3 mm long. Bracts ovate, brown, rather thin, 6 mm long or less. Flowers red, solitary, few, the pedicels slender, 6 to 7 mm long, puberulent or pubescent. Calyx a small disk about 1.5 mm in diameter. Corolla 2 cm long, 4 to 5 mm in diameter, cylindrical, slightly lepidote, the lobes 5, ovate, rounded, 5 to 6 mm long, 4 to 5 mm wide, somewhat spreading. Stamens 10, unequal; filaments glabrous; anthers 1.4 mm long. Ovary oblong, 5-celled, about 3.5 mm long, densely lepidote; style glabrous, about 18 mm long.

MINDANAO, Province of Misamis, Mount Malindang, *For. Bur. 4705 Mearns & Hutchinson*, May, 1906. Common in forests at about 1,800 m. alt.

MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4705 Mearns and Hutchinson* (M, W): Agusan Province, Mount Urdaneta, *Elmer 13695* (M, W, C): Bukidnon Province, Mount Candoon, *Bur. Sci. 38929 Ramos and Edaño* (M, W). CAMIGUIN, Camiguin Volcano, *Bur. Sci. 14661 Ramos* (M, W).

Distinguish chiefly by the length of the tubular corolla. The buds are rather large, the scales slightly lepidote and some-

times very slightly hairy. The pedicels are lepidote as well as pubescent.

F. Forma DAVAOENSE forma nova.

Suffrutices terrestres, foliis fere obovatis, emarginatis, 15 mm longis, 8 mm latis, venulis manifestis. Gemmae 6 mm longae, bracteis fere glabris. Flores solitarii, pedicellis lepidotis et puberulentis, corolla tubulosa, 20 ad 25 mm longa. Fructus rectus vel arcuatus, 10 ad 15 mm longus.

MINDANAO, Davao Province, Mount Apo, *Williams 2543* (M, W; type of the form), *De Vore and Hoover 287* (M), *Copeland 1036* (M), *Mearns* (W), *Elmer 11656* (W), *Clemens 15652* (C) : Cotabato Province, Mount Matutum, *Copeland s. n.* (M).

Describing his specimen cited above, Elmer remarks as follows, under the heading *Rhododendron quadrasianum* Vidal:

> A stocky tree in a dense moss covered forested basin of Apo at 6,500 feet, near Baclayan, a cold and alpine camping place; wood hard and reddish toward the center, covered with brown shredded bark; leaves suberect, numerous, shining, bright green above, much paler and punctate beneath; flowers not numerous, bright blood red, pendulous, 0.5 inch long or longer, cylindric. "Tongog" is the Bagobo name.

Distinguishable from variety *malindangense* by the size and shape of the leaves.

G. Var. INTERMEDIUM Merrill.

Var. *intermedium* MERRILL in Philip. Journ. Sci. 3 (1908) Bot. 382; Enum. Philip. Fl. Pl. 3 (1923) 244.

Arbor parva, foliis parvis superne valde convexis, 10 mm longis, 2 mm latis. Gemmae 3 mm longae, bracteis glabris. Flores solitarii, pedicellis minute hirsutis, minime lepidotis, corollis campanulatis, 10 mm longis. Fructus circa 8 mm longi.

LUZON, Zambales Province, Mount Tapulao, *For. Bur. 8063 Curran and Merritt* (M, W; type of the variety), *Bur. Sci. 5082 Ramos* (M), *For. Bur. 8086 Curran and Merritt* (M); Mount Pinatubo (specimens with larger leaves), *Bur. Sci. 2539 Foxworthy* (M), *Clemens 17474* (C) : Mountain Province, Benguet Subprovince (specimens with larger buds), *Bur. Sci. 5722 Ramos* (M), *Bur. Sci. 40316 Ramos and Edaño* (M, W), *For. Bur. 15840 Curran and Merritt* (M) : Abra Province, Mount Paraga (leaves and buds larger than the type), *Bur. Sci. 7104 Ramos.*

The specimens here cited are not alike in all respects, but all have glabrous bud-scales and pedicels which are hairy but not lepidote. The group is very close to var. *rosmarinifolium.*

H. Var. ROSMARINIFOLIUM (Vidal) comb. nov.

Rhododendron rosmarinifolium VIDAL, Rev. Pl. Vasc. Philip. (1886) 172; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 43; Philip. Journ. Sci. 2 (1907) Bot. 292, 3 (1908) Bot. 382; Enum. Fl. Pl. Philip. 3 (1923) 245; MILLAIS, Rhodod. (1917) 236, 2d ser. (1924) 225; RENDLE in Journ. Bot. 34 (1896) 355.

Vidal's original description is as follows:

Frutex vel fruticulus; ramis validis, teretibus, cortice cinereo; ramulis rufo-brunneis, rimosis. Folia oblongo-linearia, basi in petiolum brevissimum angustata, apice rotundata vel emarginata, longa 1-2 cm. lata 3-5 mm., margine revoluta, supra nitida; subtus ochracea ferrugineo-punctata, aven a [misprint for avenia]; nervo medio subtus prominente, ferrugineo. Gemmæ floriferæ perulatæ; squamis rotundatis, ciliolatis. Flores rubri, 1 cm. longi, pedicellati; pedicellis pilosis. Calyx obsoletus vel parvus, patelliformis, obscure dentatus. Corolla campanulata; lobis 5 brevibus, rotundatis. Stamina 10, exserta. Ovarium lepidotum. Capsula 5-valvis, valvis lignos s [misprint for lignosis] dein recurvatis; cylindraceo-lobata. basi leviter angustata, 10–15 mm. longa 3 mm. lata, pedicello paulum longior. Semina minuta, texta utrinque in appendiculum subulatum producta, ad lentem tenuiter striata.

1530 Distr. Bontoc (N. v. *Vicbiqui.*)

LUZON, Mountain Province, Benguet Subprovince, Mount Santo Tomas, *Elmer 5798* (M, W), *Williams 1335* (M, W), *For. Bur. 14167 Merritt* (M), *McClure 16014* (C), *Merrill 11744* (M, W), *For. Bur. 25129 Leaño* (M, W), *Bur. Sci. 45095 Ramos and Edaño* (M), *Clemens 5880* (C); La Trinidad, *Elmer 6377* (M, W); Baguio (?), *Elmer 14285* (M, W), *Elmer 8588* (W); Pauai, *Bur. Sci. 31988 Santos* (M, W), *Bur. Sci. 8423 McGregor* (M); no specific locality, *Loher 3767*: Lepanto Subprovince, Mount Data, *For. Bur. 14453 Darling* (M, W), *For. Bur. 10949 Curran* (M): Bontoc Subprovince, Mount Caua, *Bur. Sci. 38072 Ramos and Edaño* (M).

The Mountain Province is the home of several distinct linear-leaved forms of *R. quadrasianum.* The commonest of these, and the one which I regard as typical of Vidal's *R. rosmarinifolium,* is represented by the specimens cited above. These have buds about 7 millimeters long, the scales lepidote, sometimes hairy in addition; pedicels hairy and lepidote; flowers commonly clustered.

I. Forma PULOGENSE forma nova.

Suffrutices ad 1 m alti, interdum epiphytici. Folia linearia ad ovalia, usque ad 15 mm longa, 5 mm lata. Gemmae ad 11 mm longae, squamis lepidotis et minute puberulentibus. Flores vulgo glomerati, pedicellis lepidotis, non pubescentibus, corollis campanulatis, 10 ad 15 mm longis. Fructus circa 8 mm longi.

LUZON, Mountain Province, Benguet Subprovince, Mount Pulog, *Bur. Sci. 44944 Ramos and Edaño* (M, C; type of the form); Mount Santo Tomas, *For. Bur. 5034 Curran* (M), *Merrill 11744* (C), *Bur. Sci. 40095 Ramos and Edaño* (C); Pauai and neighborhood, *Merrill 4752* (M, W), *Clemens 16394* (C): Lepanto Subprovince, Bauko, *Vanoverbergh 277* (M): Ifugao Subprovince, Mount Polis, *Bur. Sci. 19736 McGregor* (M, W).

J. **Forma BANAHAOENSE forma nova.**

Frutex parvus, foliis anguste ellipticis, retusis, usque ad 30 mm longis, 7 mm latis. Gemmae 6 mm longae, bracteis sparse puberulis. Pedicelli pubescentes, sparse lepidoti. Flores solitarii vel bini. Corolla aurantiaca, tubuloso-campanulata, circa 10 mm longa. Fructus robusti, 10 mm longi.

LUZON, Laguna Province, Mount Banahao, *Cuming 804* (M; type of the form), *For. Bur. 7888 Curran and Merritt* (M), *Loher 6178, 13682* (M), *Bur. Sci. 19588 Ramos* (M, W), *Bur. Sci. 9847 Robinson* (M), *Quisumbing 1312* (M).

Common on the summit of Mount Banahao. Resembles var. *rosmarinifolium*, but is widely separated geographically and has somewhat larger leaves.

The following extra-Philippine groups are to be mentioned:

K. **Var. CUNEIFOLIUM (Stapf) comb. nov.**

Rhododendron cuneifolium STAPF in Trans. Linn. Soc. Bot. 4 (1894) 198, t. 15, f. B, 3; GIBBS in Journ. Linn. Soc. Bot. 42 (1914) 104; MERRILL, Enum. Bornean Pl. (1921) 461; MILLAIS, Rhodod. (1917) 150, 2d ser. (1924) 121; RENDLE in Journ. Bot. 34 (1896) 355.

Stapf's original description is as follows:

Arbor humilis. Ramuli *graciles*, novelli badii, demum albo-cinerascentes. Folia petiolo 1 lin. longo suffulta, *obovato-cuneata, 6–8 lin. longa, superne 2 lin. lata,* basi longe cuneatim in petiolum attenuata, apice rotundata, emarginata, margine leviter recurvo, impresso-punctata, coriacea, utrinque sparsim lepidota, supra demum glabrata, lucida, uninervia, costâ supra impressâ. Flores terminales solitarii vel bini e gemmâ perulatâ, ovoideâ, acutâ, 2 lin. longâ. Perulæ paucæ, ovatæ, exteriores breviores, sericeo-ciliatulæ. Pedicelli filiformes, 2 lin. longi, *dense lepidoti.* Calyx breviter 5-lobatus, lepidotus. Corolla rubra, *tubulosa, superne sensim leviterque dilatata,* 5 *lin. longa,* extus lepidota; lobi 1–1½ lin. longi, porrecti (an semper?), ovati, margine suberosuli. Stamina 10; filamenta filiformia, glabra, breviter exserta; antheræ ovato-globosæ, ½ lin. longæ. Ovarium dense lepidotum; stylus tenuis, glaber, 3 lin. longus.

At 7000 feet[3] (*Haviland,* 1180).

[3] On Mount Kinabalu, British North Borneo—H. F. C.

Allied to *R. Vidalii,* Rolfe, *R. apoanum,* Stein, *R. rosmarinifolium,* Vid., and *R. quadrasianum,* Vid., but distinct by the very narrow cuneate leaves and the rather tubulose corolla. Of these I know *R. rosmarinifolium* only from Vidal's description; I have seen the other three. According to Vidal, *R. rosmarinifolium* differs by robust branches, oblong linear leaves, smaller bell-shaped flowers, and hairy pedicels. *R. apoanum* is a native of Mindanao, *R. quadrasianum* inhabits South and Central Luzon, whilst *R. Vidalii* (=*R. verticillatum,* Vidal, non Low) and *R. rosmarinifolium* were found in North Luzon. They all come very closely together.

Rhododendron vidalii is actually very distinct from the *R. quadrasianum* group; while *R. apoanum* is a rather close relative, having ciliate bud-scales, glabrous filaments, and subglobose anthers with gaping pores, but is quite distinct. I have not seen typical material of Stapf's species, with lepidote pedicels; but all the characters mentioned by Stapf as distinctive are shared by one or more of the varieties mentioned above.

I have not seen type material of *R. quadrasianum* var. *subspathulatum* Ridley. The original description is very inadequate. The specimens that I have seen under this name constitute an undescribed species in a different group.

The descriptions of *Rhododendron quadrasianum* var. *borneense* J. J. Smith and *R. rosmarinifolium* var. *villosum* J. J. Smith, mentioned by Merrill,[4] from Dutch Borneo, do not seem to have been published; at least I have been unable to locate them.

2. **RHODODENDRON APOANUM Stein.**

Rhododendron apoanum STEIN in Verhandl. schles. Gesellsch. vaterländ. Cultur Breslau 1883 (non vidi); Gartenflora **34** (1885) 194, t. 1196; ELMER in Leafl. Philip. Bot. **3** (1911) 1107; MERRILL in Govt. Lab. Publ. (Philip.) **29** (1905) 43; Philip. Journ. Sci. **3** (1908) Bot. 380; Enum. Philip. Fl. Pl. **3** (1923) 243; MILLAIS, Rhodod. (1917) 115, 2d ser. (1924) 83; VIDAL, Rev. Pl. Vasc. Filip. (1886) 172.

Rhododendron sp. VIDAL, Sinopsis Atlas (1883) 30, t. 60, f. E.

Rhododendron jasminiflorum F.-VILLAR, Novis. App. (1883) 353, non Hooker.

Stein's description (1885) is as follows:

R. apoanum Stein (in Verhandlungen der schlesischen Gessellschaft für vaterländische Cultur in Breslau 1883): Zwergstrauch, mit aufsteigenden reich verzweigten Aesten, die jüngern Aeste dicht braunschuppig bekleidet. Blätter kurz gestielt verkehrteiförmig, allmählig in den Blattstiel verlaufend, abgestumpft, ganzrandig, Blattrand zurückgesclagen, Oberseite glänzend dunkelgrün, dicht schuppig-grubbig punktirt und

[4] Enum. Born. Pl. (1921) 462, 463.

dadurch in trockenen Zustande weisslich schimmernd, Unterseite glänzend broncefarben, fast goldschimmernd dicht schuppig bekleidet. Blüthen in dichten Doldensträussen, kurz getielt, Stiele und Kelche dicht broncirt schuppig. Kelch klein, fünfzackig. Blumenröhre cylindrischglockig, unbekleidet, Saum wenig ausgebreitet, fünflappig, Lappen fast kreisrund, leicht herezförmig eingebuchtet, wellig-bogig, purpurroth. Staubfäden zu 5, nicht vortretend. Griffel kurz, g[e]rade, auf kruzen dickem Fruchtknoten, Narbe kopfförmig. Frucht ??

Unter dem Gipfel des Vulkan Apo auf Sud-Mindanao (Philippinen) bei 3,000 m weit verbreitet. (Dr. Schadenberg, February 1882.) Die schöne Pflanze erinnert in der Tracht so an unser alpines Rhododendron ferrugineum, das es leicht erklärlich ist, wenn unser Sammler sie im ersten Augenblick auch dafür hielt und leider nur spärliches Material dieser reizenden Alpenrose sammelte, welche sich eng an Rhododendron setusum und lepidotum aus dem Himalaya anschliesst und diese Arten mit unseren Alpenrosen verbindet.

Die Astbildung und der ganze Wuchs des nur halbmeterhohen Strauches erinnert ganz an unsere Alpenrosen, während froilich die ebenso dichte wie schöne Schuppenbekleidung, welche die ganze Pflanze wie mit Bronce übergossen erscheinen lässt, den Botaniker auf den ersten Blick die neue Art erkennen lässt. Die festen, lederigen Blätter messen bis 6 cm Länge bei 2,5 cm Breite und sitzen 1–1,5 cm langen Stielen, in welche sich die Blattspreite allmählich zusammenzieht. Nach der Spitze zu zieht sich das Blatt plötzlich zusammen und endet in eine kurze, breit abgerundete Spitze. Blüthen zu 6–10, fast von der Form des Rhododendron hirsutum, aber völlig unbekleidet. Blumenröhre bis 2 cm lang, Saum bald zurückgeschlagen, ausgebreitet etwa 2 cm in Durchmesser, von prächtig purpurrothe Färbung.

MINDANAO, Davao, Province, Mount Apo, *DeVore and Hoover 239, 375* (M), *Copeland 1045, 1140* (M, W), *Mearns s. n.* (W), *Williams 2559* (M), *Elmer 10630, 11386* (M, W), *Clemens 15653, 15667* (C): Bukidnon Province, Mount Lipa, *Bur. Sci. 38497 Ramos and Edaño* (M, C): Agusan Province, Mount Urdaneta, *Elmer 13754* (M).

Elmer's field notes are of interest:

Field note for 11386:—An erect shrub, 3 feet high; stems usually several, numerously branched above the middle; the suberect twigs grayish brown; leaves numerous, ascending, grayish brown beneath or the young ones scurfy brown on both sides; flowers terminal or upon short special stalks, quite numerous and forming dense blood red cluster; corolla broadly cylindric, 0.75 inch long, upon glandularly scurfy pedicels. This the Bagobos call "Calumping-busau."

To these descriptions the following notes may be added. The bud scales have white-ciliate margins. The outer bud scales are densely lepidote; the inner are progressively larger and less lepidote. There are 6 to 15 flowers in the umbel. The corolla is definitely lepidote externally, although very sparingly, often

with only a single scale near each sinus of the limb. The stamens are represented as eight in number in the figures of both Stein and Vidal. I have dissected the flowers from about a dozen collections, and have found the stamens to be always ten in number. The pistil is 7 to 9 mm long, densely lepidote for about two-thirds of its length. I have seen fruit only on Williams's collection. The fruit is about 2 cm long, and is that of a typical *Vireya:* the five linear valves break loose at the apex and become recurved, while the filiform placentæ tear loose, except at the apex, from the central column. Each seed is more than 1 mm long and bears a filiform appendage 2 mm long at each end.

As to variations, Elmer remarks as follows:

Represented by numbers 11386 and 10630, *Elmer*, Todaya (Mount Apo), Mindanao, August and May, 1909.

The former is typical *R. apoanum Stein.* The latter number was collected on a wooded ridge at 7,500 feet of mount Calelan, and had a subscandent epiphytic habit. *Stein's* species came from the chaparral region of Apo, since none of the former botanists have explored mount Calelan Number 10630 is somewhat similar to *R. nortonae Merr.* which the writer also collected in southern Negros.

The existence of two forms, suggested by Elmer, is evident in the considerable body of material that I have examined. One of the forms has entire leaves, of the dimensions given in the original description. These leaves are spreading rather than ascending, just as in the plant from which Stein's drawing was made. This is, I believe, to be regarded as the typical form. To it belong *Elmer 10630,* as well as the specimen from Bukidnon and part of the material from Mount Apo. The other (and apparently commoner) form has slightly smaller leaves, which are very feebly dentate toward the apex, and tend to ascend strictly. There is not the least difference in the flowers; I believe that not even a varietal distinction can be made. The specimen of *Copeland 1440* in the herbarium of the Bureau of Science has both forms mounted on the same sheet, with the note in the collector's handwriting, "If 2 species, they have the same range."

The specimen from Agusan is without flowers. It is possible that it represents an undescribed species; the leaves are narrower and more scattered than those of specimens from the type locality.

3. RHODODENDRON NORTONIAE Merrill.

Rhododendron nortoniae MERRILL in Philip. Journ. Sci. 1 (1906) Suppl. 220; Enum. Philip. Fl. Pl. 3 (1923) 244; ELMER, Leafl. Philip. Bot. 3 (1911) 1107; MILLAIS, Rhodod. (1917) 218, 2d ser. (1924) 195.

An epiphytic shrub with lanceolate to oblong-lanceolate, coriaceous, acuminate leaves which are densely brown lepidote beneath, and terminal umbellate-like fascicles of tubular crimson flowers about 4.5 cm. long. Branches terete, brown, the branchlets densely covered with round, dark-brown scales. Leaves 9 to 15 cm. long, 1.5 to 3.5 cm. wide, narrowed below to the acute base and above to the rather long slender apex, entire, the margins slightly recurved, glabrous and shining above, densely covered with small round dark-brown scales beneath; lateral nerves 5 to 6 on each side of the midrib, distant, indistinct; petioles densely lepidote, stout, 1 cm. long or less. Umbels terminal, about 12 flowered, the bud bracts coriaceous, glabrous except the slightly pubescent margins, ovate to oblong-ovate, acute, 1 to 1.7 cm. long. Pedicels 1.3 cm. long, glabrous, the bracts oblong to spatulate the bracteoles filiform, caducous. Calyx a disk about 3 mm. in diameter, obscurely 3-toothed, the teeth rounded, small. Corolla 4.5 cm. long, scarlet, the tube cylindrical, about 3.5 cm. long, scarcely inflated or enlarged above, slightly curved, 6 to 7 mm. in diameter, the limb 5-lobed, the lobes broadly ovate to obovate, rounded, 1 cm. long. Stamens 10; anthers oblong, 3.5 mm. long. Ovary narrowly oblong, the style elongated filiform, densely brown lepidote.

MINDANAO, Lake Lanao, Camp Keithley (500 *Mrs. Clemens*) April, 1906. Altitude about 800 m. Epiphytic on a large tree, associated with an epiphytic *Vaccinium*.

At the collector's request this distinct species is named in honor of Miss Norton, of the Pacific Grove (Calif.) Museum, the collector's interest in botanical work having been largely inspired by her.

Rhododendron nortoniae is apparently very rare. I have seen no specimen except the type in the herbarium of the Bureau of Science collected twenty-two years ago. There is no record of another collection except a statement by Elmer that he has collected this species in southern Negros.

The species is related to *R. apoanum*, but perhaps not very closely. An interesting difference is found in the stamens, which are in this species densely brown-pubescent in the lower part.

4. RHODODENDRON CATANDUANENSE Merrill MS. sp. nov.

Fruticulus epiphyticus, dense lepidotus ad ramulos juniores, petiolos, faciesque inferiores foliarum; foliis ad nodos confertis, repandis, coriaceis, angusto-ellipticis, utrinque attenuatis, supra nitidis, 5 ad 10 cm longis, 1 ad 2 cm latis, petiolis 1.5 cm longis;

floribus ignotis (terminalibus, 15 in umbella?); fructibus subgeneris Vireyae typicalibus, 5 ad 8 cm longis, dense lepidotis; pedicellis crassis, 2 cm longis; seminibus fusiformibus, plus quam 1 mm longis utrinque appendiculatis, appendiculis seminibus aequantibus.

CATANDUANES, Mount Mariguidon, *Bur. Sci. 30346 Ramos,* November 14, 1917, altitude 270 meters.

This species is certainly distinct from any other described from the Philippines and appears to be very rare. It is related to *R. apoanum* and *R. nortoniae;* the leaves closely resemble those of the latter species, but are smaller.

These four Philippine species represent three distinct series. The first, and apparently the most primitive, is characterized by moderately lepidote leaves, filiform styles, and glabrous filaments. Close to *R. quadrasianum,* the Philippine representative, are *R. retusum* (Bl.) Ben. and perhaps *R. ericoides* Low, the former widely distributed in the Malay region, the latter confined to British North Borneo. The leaves of *R. retusum* are larger than those of *R. quadrasianum,* the fruits are similar, and the seeds bear shorter appendages, one of the appendages on each seed being fimbriate.

The second series is characterized by densely lepidote leaves and pubescent filaments; the styles are various. Of this group *R. nortoniae,* with filiform styles, seems to be an extreme example; I assume that the flowers of *R. catanduanense* are very similar. The Javan *R. zollingeri* J. J. Sm., and the Bornean *R. acuminatum* Hook f., *R. durionifolium* Becc., *R. lineare* Merr., *R. mjobergii* Merr., and *R. variolosum* Becc. are similar but have stouter styles.

The third series is characterized by densely lepidote leaves, glabrous filaments, and stout styles. The Philippine *R. apoanum* is as Merrill [5] points out, very close to *R. malayanum* Jack (*R. tubiflorum* and *celebicum* DC., Miq., *Vireya* Blume); the latter is, however, a species of low elevations, with pistils nearly 2 cm long, lepidote for less than half their length.

The whole group is a natural one. The characters of the budscales, ovaries, fruits, and seeds lead me to include it in the section *Lepipherum;* I have, however, hesitated, because I am not certain that the various subsections of *Vireya,* described below, have a common ancestor outside of this group.

[5] Enum. Philip. Fl. Pl. 3 (1923) 243.

Section VIREYA Blume as genus

Vireya BLUME, Bijd. (1826) 854–855.
Vireya G. DON, Gen. Syst. 3 (1834) 846.
Rhododendron Subg. I *Eurhododendron* Sect. 2 *Vireya* DRUDE in Engler and Prantl Natürl. Pflanzenf. 4[1] (1897) 36.
Not *Rhododendron* Series I *Eurhododendron* Subseries 8 (*Vireya* Blume) HOOKER f., Gen. Pl. 2 (1876) 600.

A large group of which the type is *R. javanicum* (Bl.) Benn. The group ranges from the Malay Penisula, through the Malay Archipelago, to New Guinea, and the Philippines, with one species in Formosa [6] and possibly one in the Himalayas.

The leaves are always moderately lepidote. The bud-scales are typically large, rounded, and entire; in a single form, which I regard as referable here, the margins are white-ciliate. The corolla is usually rather broadly tubular with a flaring mouth. Typically the ovary is pubescent; it varies to moderately lepidote or glabrous. The seeds bear filiform appendages longer than themselves.

My subseries 1 and 2 fall within this definition; they are placed here provisionally, although I suspect them of an independent descent from section *Lepipherum*. For the rest, I have confidence that the group is a natural one.

Subsection 1, MALESIA

Filaments glabrous, ovary pubescent. The following is the type species.

5. **RHODODENDRON BAGOBONUM** sp. nov.

Fruticulus epiphyticus?, ramulis junioribus brunneis, sparse lepidotis. Folia pseudoverticillata, sessilia, oblanceolata, 2 cm longa, apice acuta, basi cuneata superne atroviridia, subtus lucida, utrinque lepidota, venulis obscuris vel obsoletis. Bracteae angustae, glabrae, basi in tomentum brevum implicatae. Flores solitarii, terminales. Pedicelli 5 mm longi, lepidoti pubescentesque. Calyx vix evidente. Corolla rubra, 1 cm longa, glabra, campanulata, lobis 5, parvis, rotundis. Ovarium 5-loculare, dense albo-pubescente. Fructus fusiformis, 2 cm longus, pubescens. Semina fulva, fusiformia, minus quam 1 mm longa, utrinque appendiculata; appendiculis filiformibus, 3 mm longis. (Bagobones: tribus in quarum finibus planta crescit.)

MINDANAO, Davao Province, Mount Apo, *Mrs. Clemens,* June, 1924, type in the herbarium of the University of California, sheet No. 268274.

[6] Wilson, Journ. Arn. Arb. 6 (1925) 173.

This distinct species is described from a single specimen, which bore, unfortunately, only a single flower, and that partly destroyed by insects. I believe, but cannot affirm confidently, that the plant is an epiphyte, and that there are ten stamens with glabrous filaments. It resembles superficially *R. quadrasianum*.

Rhododendron bagobonum is decidely distinct from all other Philippine species. It is close to the Bornean form which I have seen under the name of *R. cuneïfolium* var. *subspathulatum* Ridley. The latter has bud-scales with ciliate margins and appears to connect *R. bagobonum* with *R. quadrasianum*. To the same group I refer the New Guinean *R. linnaeoides* and *R. torricellense* of Schlechter, of which I have seen cotypes. These have acuminate bud-scales with brown-fimbriate margins; they seem to represent a transition to the following section.

Subsection 2. LINEARANTHERA

Bud-scales acuminate, brown-fimbriate. Corolla lepidote or hairy without, hairy within. Ovary and stamens pubescent. Anthers linear. The type species is *R. vidalii* Rolfe.

6. RHODODENDRON VIDALII Rolfe.

Rhododendron vidalii ROLFE in Journ. Bot. 24 (1886) 348; MERRILL in Govt. Lab. Publ. (Philip.) **29** (1905) 43; Philip. Journ. Sci. **1** (1906) Suppl. 111, **3** (1908) Bot. 381; Enum. Philip. Fl. Pl. **3** (1923) 245; MILLAIS, Rhodod. (1917) 258, 2d ser. (1924) 257.

Rhododendron verticillatum VIDAL, Rev. Pl. Vasc. Filip. (1886) 171; Ceron, Cat. Pl. Herb. Manila (1892) 106, non Low.

Rhododendron lussoniense RENDLE in Journ. Bot. 34 (1896) 356; MERRILL in Govt. Lab. Publ. (Philip.) **29** (1905) 43; MILLAIS, Rhodod. (1917) 204, 2d ser. (1924) 179.

Vidal's original description is as follows:

Frutex glaber; cortice albicante; ramulis sæpissime verticillatis, nodosis, junioribus rufo-brunneis. Petioli brevissimi circ. 3 mm., validi, complanati, rugosi. Folia e basi cuneata, oblonga vel obovato-oblonga, apice rotundata vel subemarginata, longa 25-45 mm. lata 10-20 mm. margine revoluta, supra nitida, subtus ferruginea vel ochracea dense scrobiculato-punctata, coriacea, in verticillastros sæpissime disposita et ramulorum apices versus conferta. Gemmæ floriferæ majusculæ ad 15 mm. longæ, perulatæ; squamis amplis rotundatis, apice acutis vel mucronatis, brunneis pallide marginatis. Flores ad ramulorum apices glomerati, albi. Calyx parvus, patelliformis, obscure dentatus, cum pedicello villosus. Corolla alba, ad 3 cm. longa, campanulata, quinqueloba, lobis rotundatis, limbo ad 3 cm. diam. Stamina 10 inclusa vel antheris sub-exsertis. Ovarium cum stylo praeter apicem velutino-setosum vel hirsuto-setosum, pilis albidis, loculis 5 (an semper?) (Series I. *Eurhododendron*, Maxim. subser. 4).

1529 Distr. Bontoc, 1.000–1.200 m. alt. (N. v. *Lofong.*)

LUZON, Mountain Province, Ifugao Subprovince, Mount Polis, *Whitehead* (M; fragment of type of *R. lussoniense* Rendle ex Herb. Mus. Brit.), *Sandkuhl 283* (M): Bontoc Subprovince, Mount Caua, *Bur. Sci. 37983 Ramos and Edaño* (M, W): Lepanto Subprovince, Bauko, *Vanoverbergh 70* (M), Sabangan, *For. Bur. 10693 Curran* (M, W): Benguet Subprovince, Loö, *Loher 3761* (W): Isabela Province, Bayabat, *For. Bur. 18559 Alvarez* (M, W): Cagayan Province, Cagua Volcano, *Clark s. n.* (M): Abra Province, *Bur Sci 7229 Ramos* (M): Bataan Province, Mount Mariveles, *Merrill 3743* (M, W), *Whitford 452* (M, W), *For. Bur. 1591 Borden* (M, W), *Merrill 3868* (M), *Merrill Decades 300* (M, C): Rizal Province, *Loher 12586* (M, C): Laguna Province, Mount Maquiling, *Elmer 17881* (M, W, C), *McLean s. n.* (M); Lukban Cone, *Elmer 7475* (M): Batangas Province, Mount Malarayat, *For. Bur. 7839 Curran and Merritt* (M).

In a footnote to his review of Vidal's Revision de Plantas Vasculares Filipinas, Rolfe[7] remarks:

As there is already a *Rhododendron verticillatum* Low in Journ. Hort. Soc. iii. pp. 86 & 87, with figure; Hook. Ic. Pl. t. 884; from Borneo, I propose to call this *R. Vidalii.*—R. A. R.

Rendle's original description of *Rhododendron lussoniense* is as follows:

Lignosus, ramis glabris brunneis; foliis oblanceolatis, facie superiore glabra, inferiore squamulis glandulosis nigris notata; bracteis castaneo-brunneis, glabris, ovatis, mucronatis; pedicellis pubescentibus, flores haud æquantibus; calyce parvo patelliforme; corolla alba inter mediocres, tubo infundibuliforme cum glandulis brunneis externe notato, lobis, tubum aequantibus, cuneato-spathulatis; staminibus 10, filamentis in parte inferiore pubescentibus superne glabris; ovario piloso 5-loculare.

Hab. North-west-central Luzon, highland of Lepanto.

The stiff woody leafy shoots of the third season are 3 mm. in diameter, and bear the leaves crowded near the ends. The petioles are short (4–5 mm. long), the blades 4.5–5.5 cm. long, 1.2–1.7 cm. broad; the lower surface bears numerous roundish black scales. The smooth bracts are 6–12 mm. long. The pedicels are 2.5 cm. long; the flowers, which have been pink or tinged with pink, 3 cm. long and about the same across. The corymb in the single specimen is 3-flowered. The calyx is reduced to a flattened plate with 5 scarcely indicated lobes. The corolla-tube and lobes are each 2 cm. long; the former is 1 cm. across the mouth, the latter are entire, with a slightly emarginate apex, and 16 mm. broad in the spreading upper part. The stamens including the anthers (4 mm.) are 2.5 cm. long, of equal

[7] Journ. Bot. 24 (1886) 348.

length with the pistil. The ovary and lower part of the columnar style have numerous short hairs.

Near the Indian *R. formosum* Wall., but distinguished by its smaller flowers.

Rendle's description is seen to agree with Vidal's except for slight variations in some of the measurements, and in the statement that the flowers are pink. This is an error: the type specimen of *R. lussoniense* (seen by Merrill) bears the field note, by Whitehead, "flowers pure white." As the type locality falls within the type region of *R. vidalii,* Merrill (1908) reduced Rendle's species; and no evidence has appeared, in the numerous collections made since, that it exists as a distinct race.

As occurring in the Mountain Province, this is a shrub 1 to 2 meters high with white flowers and narrow leaves which are green beneath. The scales on the leaves are about 0.1 mm in diameter, and 0.25 to 0.5 mm apart. The bud scales are brown and minutely and sparsely sericeous toward the middle part of their surface otherwise sparsely lepidote; they are sharply acuminate and have minutely fimbriate margins. The flowers are usually in clusters of two or three, but may be solitary. The corolla tube is lepidote without and sparsely hairy within, and the stamens, with dark, narrow anthers, are white-hairy toward the base. The fruits are 1.5 to 2 cm long, pubescent; the valves in dehiscence become recurved, and the placentæ become completely detached from the central column. The seeds are slightly more than 1 mm long and bear appendages about as long as themselves.

The specimens from Cagayan and Isabela are almost indistinguishable from those from the Mountain Province, but the pedicels are glabrescent and lepidote. The specimen from Abra has peculiarly small flowers. The specimens from Bataan, Rizal, Laguna, and Batangas are sometimes described in the field notes as epiphytes and have shorter, more nearly oval, leaves, which, when dry, are reddish brown beneath. This species shows, in fact, a tendency like that of *R. quadrasianum* to assume a distinct form on each mountain top; but it does not appear worth while to separate the forms taxonomically.

7. RHODODENDRON WHITEHEADI Rendle.

Rhododendron whiteheadi RENDLE in Journ. Bot. 34 (1896) 356; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 43; Philip. Journ. Sci. 3 (1908) Bot. 381; Enum. Philip. Fl. Pl. 3 (1923) 245; MILLAIS, Rhodod. (1917) 262, 2d ser. (1924) 260.

Rhododendron curranii MERRILL in Philip. Journ. Sci. 3 (1908) Bot. 255, 381; Enum. Philip. Fl. Pl. 3 (1923) 243; MILLAIS, Rhodod. (1917) 151, 2d ser. (1924) 121.

Rendle's original description is as follows:

Lignosus, ramis duris rigidis, ramulis glabris pubescentibus; foliis obovatis, interdum orbiculari-obovatis rarius ovalibus, apice rotundo vel emarginato, basi sæpius cuneata, facie superiore glabra atre viride, inferiore glandulis crebris punctata; bracteis ovatis obtusis minute puberulis, pedicellis validis quam flores brevioribus velut calyce pubescentibus; calyce parvo patelliforme; corolla inter mediocres atre purpurea, campanulata lobis truncate obovatis cum apice lato rotuso, æquantibus; staminibus 10 inæqualibus basi lata breviter pilosis; ovario 5-loculare conico dense piloso, stylo super basin pilosam globro apice clavato.

Hab. North-west-central Luzon, highland of Lepanto.

The woody shoots are stiff and hard, with the leaves closely crowded at their ends; shoots of the third season are 3 mm. in diameter. The short stout pedicels [*sic!* should be *petioles*] are 4–5 mm. long; the leaves 2.5–4.5 mm. [*sic!* should me *cm.*] long, 1.5 to nearly 3.5 broad. The pale brown bracts are 9–13 mm. long, the pedicels 13 mm. The deep crimson bell-shaped flowers are borne in umbels of three, and are 2.5 cm. long by 2.75 cm. across. The slightly pubescent corolla-tube is 12 mm. long; the lobes are 12 mm. long, and 12 mm. across the top. The stamens including the anthers (3 mm.) are 17–20 mm. long; the ovary 1.5 cm.

Near the Bornean *R. verticillatum* Low, but distinguished by the shape of its leaves, especially the marked tendency to a wedge-shape, the few-flowered inflorescence, and the hairy, not scaly, pedicels and ovary.

Merrill's original description of *R. curranii* is as follows:

Arbuscula 2 ad 2.5 m alta, ramis ramulis foliisque glabris; foliis coriaceis oblongo-obovatis vel oblongo-oblanceolatis, acutis vel obtusis, basi sensim angustatis; pedicellis dense hirsuto-pilosis; floribus 2.5 ad 3 cm longis, purpureo-coccineis; staminibus 10, filamentis in parte inferiore plus minus hirsutis; ovario dense piloso.

A shrub 2 to 2.5 m high, the branches light-gray or brownish, glabrous, slender, terete, the ultimate ones 1.5 to 2 mm in diameter. Leaves whorled. 4 to 6 or 7 at each node, coriaceous, oblong-obovate to oblong-oblanceolate, glabrous and shining on both surfaces, paler beneath and with scattered small glands, 2.5 to 5.5 cm long, 0.5 to 2 cm wide, apex blunt or acute, gradually narrowed towards the cuneate or somewhat decurrent base, the margins slightly revolute; nerves obscure, about 4 on each side of the midrib; petioles 2 to 4 mm long. Flowers crimson-purplish, in terminal sessile fascicles, three or four flowers at the apex of each branchlet, the bracts smooth, inbricate, deciduous; pedicels densely hirsute-pilose, 1.5 to 2 cm long. Calyx an obscurely toothed ring about 4 mm in diameter. Corolla 2.5 to 3 cm long, slightly pubescent on the outside, the tube rather broad, the lobes orbicular-obovoid, rounded or retuse, 1.3 mm [*sic!* should be *cm*] long, 1.5 mm [*sic!*] wide. Stamens 10; filaments 1.5 to 1.8 cm long, 5-celled [*sic! delete*], slightly enlarged and hirsute below, glabrous above. Ovary oblong, 5-celled, densely pilose, 5 mm long; style glabrous, about 9 mm long.

LUZON, Province of Zambales, Mount Tapulao, *For Bur. 8061 Curran*, December, 1907, in thickets on ridges at 2,000 m alt., also from the same locality *Bur. Sci. 4988 Ramos*, December, 1907.

A species closely allied to *Rhododendron lussoniense* Rendle, differing somewhat in the shape of the leaves, shorter corolla tube and lobes and different color of the flowers. Rendle speaks of the flowers of *R. lussoniense* as having been pink or tinged with pink, but Whitehead's note on the type in the Herbarium of the British Museum says "flowers pure white."

There is nothing in these descriptions to show that these species are distinct, and I can find no distinctive characters by the examination of the following specimens:

LUZON, Mountain Province, Ifugao Subprovince, Mount Polis, *Whitehead* (M), (fragm. from type in Herb. Mus. Brit.): Benguet Subprovince, *For. Bur. 15738 Curran and Merritt* (M, W): Zambales Province, Mount Tahulao, *For. Bur. 8061 Curran and Merritt* (M, W, type of *R. curranii* Merrill), *Bur. Sci. 4988 Ramos* (M, W).

This species is evidently rare or at least local. It is a low shrub, sometimes if not always epiphytic, with dark red or purple flowers. The small size of the flowers, and their color and the pubescence of the ovary and filaments, distinguish this species from the other Philippine rhododendrons. The corolla tube is sparsely hairy without and densely hairy within. The fruit and seeds are unknown.

As noted above, I do not believe that the material from Zambales (essentially a single collection, since it was gathered by members of a single expedition on successive days) is to be regarded as distinct from the material from Mountain Province. If there is any difference, it is found in the shape of the leaves, which is rather consistently oblanceolate in the Zambales form, and varies to oval or orbicular in the lower leaves of the typical (Mountain Province) form; also in the pubescence, which is slightly less dense on the corolla, and extends higher on the style, in the typical form.

The nearest Philippine relative is *R. vidalii*. In my judgment, the Bornean *R. verticillatum* Low is not a close relative; Hooker Ic. Pl. t. 884 shows the ovary of the latter as lepidote, and the filaments as glabrous.

8. **RHODODENDRON TAXIFOLIUM Merrill.**

Rhododendron taxifolium MERRILL in Philip. Journ. Sci. **30** (1926) 419.

The original description is as follows:

Frutex, epiphyticus circiter 1 m altus, ramis glabris, ramulis glabris vel obscurissime puberlis, parce lepidotis, teretibus, 1 ad 1.5 mm diametro,

internodis 1 ad 3 cm longis; foliis numerosissimis ad nodis pseudoverticillatim-confertis, coriaceis, rigidis viridibus, linearis, 2 ad 3.5 cm longis, 1 ad 1.5 mm latis, obtusis sessilibus vel subsessilibus, subtus parce lepidotis, floribus terminalibus, solitariis vel paucis, subcampanulatis, albidis, circiter 2 cm longis, extus parce lepidotis, lobis late obovatis, rotundatis, 1 cm longis.

An epiphytic shrub about 1 m high. Branches terete, glabrous, ultimate branches slender, 1 to 1.5 mm in diameter, glabrous or very obscurely puberulent, the younger ones sparingly lepidote; internodes 1 to 3 cm long. Leaves numerous, crowded in pseudoverticles at the nodes, often twenty or more in a pseudoverticel, green, linear, sessile or subsessile, obtuse, 2 to 3.5 cm long, 1 to 1.5 mm wide, rigid, coriaceous, shining beneath (at least when young), sparingly lepidote, ultimately glabrous, the margins very obscurely crenulate. Flowers subcampanulate, white, terminal, solitary or few, about 2 cm long, their pedicels pubescent, somewhat lepidote, about 1 cm long. Calyx 3 to 4 mm in diameter, lepidote and pubescent. Corolla tube about 1 cm long, 6 mm in diameter, sparingly lepidote outside, pubescent within, the lobes broadly obovate, rounded, 1 cm long. Stamens 10, subequal, the filaments 10 to 11 mm long, pubescent below, glabrous above; anthers oblong, obtuse, 2.5 mm long. Ovary oblong, pubescent, 3 mm long; style about 6 mm long, pubescent in the lower one half, glabrous above.

LUZON, Benguet Subprovince, Mount Pulog, *Bur. Sci. 44880 Ramos and Edaño* (type), *Mrs. Clemens 15763*, February, 1925, on trees in the mossy forest, altitude about 2,700 meters.

A most remarkable species strongly characterized by its numerous, pseudoverticillate, *Taxus*-like leaves, whence its specific name.

The fruits, the septicidal capsules of a typical *Virega,* are about 1 cm long.

In the character of the flowers, this species is not very different from *R. vidalii;* it is on the other hand somewhat of a puzzle to find a related species with similar leaves.

These species, peculiar as are the leaves of *R. taxifolium,* seem to form a natural group. Their affinities are by no means obvious. I suspect that the possibility of relationship to *R. formosum* Wallich and *R. verticillatum* Low, suggested by Rendle, is imaginary. Wilson compares the Formosan *R. kawakamii* Hayata with *R. vidalii;* the description of the Formosan species does not mention the bud-scales, but nevertheless shows that there is probably a close relationship. The New Guinean *R. gorumense* Schlechter and *R. hausemannii* Warburg fall in the same group; but it is hard to recognize New Guinean or Formosan species as ancestral to Philippine *Eurhododendra.* The Bornean *R. neiuwenhuisii* J. J. Smith and *R. rugosum* Low are suggestive. The latter has the leaves densely lepidote beneath with remarkable cup-shaped scales with lacerate margins and similar scales mixed with the pubescence on the ovary; this

species indicates, possibly, a direct connection to section *Lepipherum;* or the connection may be through species resembling *R. linnaeoides* and *R. torricellense* in subsection *Malesia.*

Subsection 3. SOLENOVIREYA

Rhododendron Series I *Eurhododendron* Subseries 7 HOOK. f., Gen. Pl. **2** (1876) 600.

Bud scales about 1 cm long, rounded, with entire margins; corolla tube slender, usually flaring above, usually lepidote without and hairy within; filaments hairy, anthers small, oblong, with gaping pores; ovary cylindrical, lepidote to pubescent, varying in the same species and usually obviously both; style filiform. The type species is *R. jasminiflorum* Hooker f.

9. RHODODENDRON COPELANDI Merrill.

Rhododendron copelandi MERRILL in Govt. Lab. Publ. (Philip.) **29** (1905) 42; Philip. Journ. Sci. **3** (1908) Bot. 381; Enum. Philip. Fl. Pl. **3** (1923) 243; ELMER in Leafl. Philip. Bot. **3** (1911) 1105; MILLAIS, Rhodod. (1917) 148, 2d ser. (1924) 117.

The original description reads as follows:

A glabrous shrub 1 to 2 m. high, with narrowly obovate to oblanceolate coriaceous, obtuse or slightly acute, verticillate leaves, and many flowered terminal fascicles of white, fragrant tubular flowers 4 cm. long. Branches reddish brown, glabrous, the branchlets verticillate. Leaves in whorls at the nodes and apices of the branchlets, 4 to 6 cm. long, 1 to 2 cm. wide, glandular-punctate beneath, the apex abruptly acute or rounded, the base cuneate, tapering gradually to the stout petiole which is 8 mm. long. Peduncles 18 mm. long, sparingly brown lepidote and minutely pubescent. Calyx a small crenate disk 2 mm. in diameter. Corolla tube 4 cm. long, tubular, 4 mm. in diameter, not enlarged or inflated above, the limb abruptly spreading, 1.5 cm. in diameter, 5-lobed, the lobes obovate, obtuse, 5 to 6 mm. long. Stamens 10, the filaments filiform, glabrous, 4 cm. long, the anthers 1.5 mm. long. Ovary oblong, 5 to 6 mm. long, densely pubescent with short spreading hairs; style slightly pubescent throughout, 3.8 cm. long.

Type specimen No. 1439 (Copeland), Mount Apo, District of Davao, Mindanao, October, 1904; also from same locality, all specimens in flowers, No. 1034 (Copeland), April, 1904, and Nos. 292, 382, (De Vore and Hoover), May, 1903. A shrub 1 to 2 m. high, growing at an altitude of from 2,500 m. to the summit of the mountain, 3,100 m.

MINDANAO, Davao Province, Mount Apo, *Copeland 4139* (M, W), *Copeland 1034* (M), *De Vore and Hoover 292* (M, W), *De Vore and Hoover 382* (M), *Williams 2681* (M, W), *Elmer 11395* (M, W), *Clemens s. n.* (C).

Elmer's field note upon this species reads as follows:

Erect and numerously branched 6 feet high shrub associated with other shrubs along the Seriban creek at 7,750 feet on Apo; leaves rigid, ascending, paler green beneath; flowers spreading, rather numerous and forming pure white and somewhat fragrant clusters. This delicately pretty species the Bagobos call "Malambago."

The leaves are extremely finely brown-punctate (not lepidote) above; moderately lepidote beneath. The bud-scales are brown, oval, 1 cm long or less, with filmy margins, truncate or emarginate at the apex. The long-cylindrical corolla-tube is sparsely lepidote without, sparsely hairy within. The filaments are not glabrous but sparsely hairy. The ovary, in typical material, is clothed with a white pubescence; in some specimens the pubescence is scant or absent, and the ovary is conspicuously lepidote. I have seen fruits only after dehiscence; they are typical *Vireya* fruits, 1 to 2 cm long, the placentæ tearing completely loose from the central column, the seeds long-tailed at both ends.

This species is very close to *R. jasminiflorum* Hooker f., described from the Malay Peninsula, and reported also from Borneo and other islands of the Malay Archipelago; a species which, so far as I can learn, shows the same variability in the surface of the ovary. Hooker's species has shorter, broader, more definitely sessile leaves than *R. copelandi.*

With these species one may associate the Bornean *R. gracile* Low and *R. orbiculatum* Ridley and the New Guinean *R. bodenii* Wernham. The boundary between this group and the following is not sharp; the present group is perhaps the more primitive. The flowers resemble superficially those of *R. klossii* Ridley, of the Malay Peninsula; but I doubt the existence of a close connection. In their tubular and lepidote character they suggest a direct connection to section *Lepipherum.*

Subsection 4. EUVIREYA

Leaves large, herbaceous, often acuminate. Corolla large, with a short broad tube and flaring limb. Filaments filiform, pubescent or glabrous. Anthers obovate, often with minute appendages at the base. Ovary pubescent or sparsely lepidote, large, the style columnar, the stigma as broad as the ovary. Fruits about 3 cm long, seeds with long filiform appendages. The type species of the subsection as of the section is *R. javanicum* (Bl.) Benn., described from Java and reported also from Borneo, Sumatra, and the Malay Peninsula.

10. RHODODENDRON KOCHII Stein.

Rhododendron kochii STEIN in Verhandl. schles. Gesellsch. vaterländ. Cultur Breslau 1883 (non vidi); Gartenflora 34 (1885) 193, t. 1195; ELMER in Leafl. Philip. Bot. 3 (1911) 1105; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 41; Philip. Journ. Sci. 3 (1908) Bot. 380; Enum. Philip. Fl. Pl. 3 (1923) 168; MILLAIS, Rhodod. (1917) 199, 2d ser. (1924) 168; VIDAL, Rev. Pl. Vasc. Filip. (1886) 172.

Rhododendron sp. (affine al *Rh. javanicum* Bennett) VIDAL, Sinopsis Atlas (1883) 30, t. 60, f. F.

Rhododendron javanicum F.-VILLAR, Novis. App. (1883) 353; VIDAL, Rev. Pl. Vasc. Filip. (1886) 170, non Bennett.

Rhododendron schadenbergii MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 41, pro parte, non Warburg.

Stein's description in Gartenflora is as follows:

Baumartiger Strauch, reich verästet, die jungere Aezte glatt braunrindig. Blätter zerstreut, kursgestielt, an den blüthentragenden Astspitzen fast quirlartig dedrängt, lederig, oben glänzend dunkelgrün unten hell gelbgrün, spärlich grubig braun punktirt, ei-elliptisch, zugespitzt, ganzrandig oder verloren bogig-wellig mit leicht zurückgekrümmten Rande. Blüthen in reichblumigen Doldensträussen, gestielt, Stiele weiss schuppig, kelch sehr klein, nur als fünfeckige, flache Scheibe entwickelt, Blumenröhre kangcylindrisch, an der Basis den Kelch breit sackig überragend, oben in einen breit-tellerförmig offenen 5-spaltigen Saum ausgebreitet, Saumlappen eirund bis fast kreisrund, rein weiss, Blumenröhre aussen verloren weissschuppig. Staubfäden zu fünf, lang vortretend, mit grissen querhangenden Antheren. Griffel lang-fadig, mit kopfförmiger, grüner narbe. Frucht ? ?

Am Flusse Siriban auf-Sud-Mindanao (Philippinen) bei 2000 m als baumartige Gebüsche fast Wälder bilden von Dr. Schadenberg im Februar 1882 reich blühend gesammelt.

Wir haben schon auf Seite 5 deises Jahrganges auf die pflanzengeographische Bedeutung der Auffindung dieses Rhododendron und des nachfolgenden Rhododendron Apoanum Stein hingewiesen, weil durch diesen Fund dis Verbindungslinie der Rhododendra der centralâsiatischen Hochgebirge mit den von Ferdinand von Müller auf den Papua-Inseln und Neu-Guinea entdeckten Alpenrosen fast vollständig hergestellt wird. Die Hochgebirge dieser einzelnen Inselgruppen schienen reich an endemishen arten su sein, welche flüchtige Betrachtung wohl mit den Festlandsarten zusammenwerfen lässt, die aber bei genauerem Hinsehen sich als wesentlich verschiedene selbstständige Arten erweisen. So steht Rh. Kochii gewissen Himalaya-Arten habituell nahe, speciell dem Rh. jasminiflorum Hook. aus dem Sikkim, weicht aber in den einzelnen, Charakteren, z. B. der Kelchbildung, der Form der Blumenkronlappen und der Blätter erheblich ab.

Dr. Schatenberg, welchem wir reichliches Blüthenmaterial dieser schönen Art verdanken, welche er gemeinsam mit seinem auf Cebu (Philippinen) ansässigen Vetter O. Koch am Siriban sammelte, schildert den Totaleindruck der blüthenüberschütteten Sträucher als einen gradezu überwältigenden. Sie treten hauptsächlich als unterholz der Wälder auf, welche von mächtigen Myrtaceen, besenders Leptospermum (Glaphyria) Annae gebilded sind, stellenweis aber sind sie auf Waldblossen und an den Flussläufen

geradezu selbst waldbildend. Diese Gebüsche erreichen eine Höbe bis zu 10 m und zeigen armsdicke, dunkelbraune Einzelstämme, welche sich reich verästeln und deren jüngere Zweige glatt braunrindig, mit nicht abblätternder Rinde sind. Die dick lederigen Blätter laufen plötzlich in eine meist lange, scharfe Spitze aus und messen 12-18 cm Lange und bis 5 cm Breite. Der 2-3 cm lange Blattstiel sitzt auf einem starken Blatkissen auf und setze sich als sehr starke Mittelrippe bis zur Blattspitze fort. Die aussergewohnlich stark netzadrige Unterseite des Blattes seigt eine spärliche Uberstreuung mit dunkelbraunen punktförmigen schüppchen. Bluthen zu 10-20 auf 2,2,5 cm langen weiss schuppigen Stielen, welche sich in einem 2–3 mm! breiten flach- plattenartigen, fünfechkigen Kelch verbreiten, dessen fünf Ecken als kleine rundliche Läppchen vortreten. Die weisse, schuppenbekleidete Blumenröhre von 3–5 cm Länge tritt sackig über den Kelch heraus, ist fast cylindrisch und öffnet sich in einen schneeweissen Teller von 3–4 cm Durchmesser. Fruchexemplare liegen uns nicht vor, doch sind Abweichungen von der normalen Kapselform nach der Bildung des Fruchtknotens in unseren Bluthen nicht wahrscheinlich.

Wir haben bereits darauf hingewiesen, dass Rhod. Kochii es ausserordentlich verdiene in unsere Culturen eingeführt zu werden, und da sowohl Herr Dr. Koch, dem wir die Art widmeten, als auch Herr Dr. Schadenberg in diesem Herbste wieder nach den Philippinen zurückkehren, ist es leicht möglich, dass unser Wunsch bald Erfüllung finden wird.

MINDANAO, Davao Province, Mount Apo, *Elmer 11435* (M, W), *De Vore and Hoover 73* (M), *Mearns s. n.* (W), *Bur. Sci. 15654 Clemens* (C) : Cotabato Province, Mount Matutum, *Copeland s. n.* (M) : Misamis Province, Mount Malindang, *For. Bur. 4674 Mearns and Hutchinson* (M, W). NEGROS, Canlaon Volcano, *Merrill 7305?* (M). LUZON, Bataan Province, Mount Mariveles, *Merrill 3255* (M, W), *For. Bur. 790 Borden* (M, W), *Leiberg 6033* (M), *Whitford 450* (M, W), *For. Bur. 2117 Borden* (M, W), *Elmer 6856* (M), *Bur. Sci. 1629 Foxworthy* (M), *For. Bur. 6281 Curran* (M), *Topping 806* (M) : Laguna Province, Mount San Cristobal, *For. Bur. 28978 Canicosa* (M) ; Mount Banahao, *Whitford 958* (M, W), *Loher 6181* (M, W), *For. Bur. 7868 Curran and Merritt* (M, W), *Bur. Sci. 9834 Robinson* (M), *Bur. Sci. 19589 Ramos* (M, W), *Gates 6108* (M), *Brown s. n.* (M), *Bur. Sci. 47424 McGregor* (M, C) : Mountain Province, various localities, *For. Bur. 10961 Curran* (M, W), *Vanoverbergh 957* (M) *Clemens 732* (C), *For. Bur. 29404 Zschokke and Larava* (C).

Speaking of a part of the specimens here listed, Merrill (1908) remarks as follows:

Many of the above specimens were previously erroneously identified by me as *Rhododendron schadenbergii* Warb., from which they differ notably in the hirsute ovary. The shape of the leaves is variable, and but few

of the specimens are as prominently acuminate as shown in the original figure, and they average smaller than the measurements given in the original description. The species is described as having five stamens, but the figure apparently shows ten, the latter number agreeing with our specimens.

Elmer, referring to his specimen No. 11383, gives the following field notes:

Tree-like shrub along the Seriban creek at 6,500 feet of mount Apo, in dense woods of moss covered soil; stem 3 to 6 inches thick, 10 to 20 feet high, usually inclining; branches ascending, rather numerously and laxly rebranched; wood soft, reddish white toward the center, without odor or taste; bark brown, smoothish; leaves in whorls, ascendingly recurved from the reddish petioles, rigidly coriaceous, dark sublucid green above, much paler or yellowish green beneath; pedicels reddish; flowers white, odorless, ascendingly spreading, white [*sic*!]; filaments whitish; anthers brownish; style and stigma greenish. "Malagus" is the name given to it by the Bagobos. If I remember correctly the natives also called the large white flowered *Drimys piperita Hook.* by the same name. One must admit casual similarity in the two species representing widely different families.

This paragraph definitely established *Elmer 11435* as a topotype, typical of the species.

The distribution of the species as shown by the specimens is rather peculiar. From the great region lying between Mindanao and Luzon, I have only one specimen, *Merrill 7305*, and that, being in fruit, not certainly identified. A careful comparison, however, of the specimens from the north with *Elmer 11435*, reveals no consistent difference, except perhaps that the plants are smaller, the average height as given on the field labels being about 3 meters.

The specimen cited by Vidal as *R. javanicum* was his number 412 from Mount Banahao. It appears not to have been in flower. *Rhododendron kochii* differs from *R. javanicum* in the color of the flowers, which, in the Javan species, are orange, and in the pubescence of the ovary; it is closer to *R. teysmanni* Miquel. Both species are common throughout the Malay region; *R. teysmanni* has slightly larger leaves and flowers than *R. kochii*, and fewer flowers in the umbel; but except for the difference in color of flowers might be regarded as the same species.

Bur. Sci. 692 Foxworthy, from Mount Victoria, Palawan, is in fruit. It is very similar, but cannot positively be identified as belonging to this species. It is the only *Rhododendron* I have seen from Palawan, and apparently is the only one that has been collected there.

11. **RHODODENDRON WILLIAMSII** Merrill MS. sp. nov.

Rhododendron schadenbergii MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 40, in part; Philip. Journ. Sci. 3 (1908) Bot. 380; Enum. Philip. Fl. Pl. 3 (1923) 245, non Warburg.

Merrill's manuscript description reads in part as follows:

Arbor glabra, 4 ad 6 m alta; foliis oblongo-ovatis vel oblongo-ellipticis, coriaceis, nitidis, acuminatis, 7 ad 10 cm longis; floribus albis, 2.5 ad 3.8 cm longis; staminibus 10, filamentis glabris; ovario pauce lepidoto.

A small tree 4 to 6 m high, the branches light gray or brownish, terete. Leaves oblong-ovate to oblong-elliptical, coriaceous, shinning, paler beneath, widest in the middle, narrowed above to the short but sharply cuminate apex and below to the acute base, very obscurely glandular beneath; primary nerves about 7 on each side of the midrib, somewhat ascending, not prominent, the secondary nerves and reticulations nearly as prominent; petioles 1 to 1.5 cm long. Flowers white, terminal, the peduncle stout, short, covered with large scars; pedicels 2.5 to 3 cm long, lepidote. Calyx disciform, 5-toothed. Corolla 2.5 to 3.8 cm long, glabrous, the tube 1.8 to 2.3 cm long, slightly enlarged above, the lobes orbicular or obovate, rounded, about 1 cm long. Stamens 10; filaments glabrous; anthers about 3 mm long. Ovary oblong, slightly lepidote, not at all hairy, 5 or 6 mm long; style about 2 cm long, slightly lepidote below, otherwise glabrous. . . .

This was previously identified by me as *Rhododendron schadenbergii* Warb., but judging from Warburg's description it is not the same as that species. . . .

Rhododendron williamsii is very similar to *R. kochii* in gross and superficial characters, but is at once distinguishable by its ovary being only slightly lepidote, while in *R. kochii* the ovary is densely hirsute or pilose.

LUZON, Mountain Province, Benguet Subprovince, Baguio, *Elmer 6519* (M, W, type of the species), *Merrill 1750* (M), *Sandkuhl 132* (M); Mount Santo Tomas, *Williams 990, 1348* (M, W), *Bur. Sci. 5392 Ramos* (M); Tabio, *Loher 3763* (W): Lepanto Subprovince, Mount Data, *Bur. Sci. 40189 Ramos and Edaño* (M): Bontoc Subprovince, Mount Pukis, *Bur. Sci. 37773 Ramos and Edaño* (M, W): Zambales Province, Mount Pinatubo, *Clemens 1743* (C).

The fruits are dark oblong capsules, 15 to 25 mm long and about 5 to 7 mm thick, bearing the persistent style which is about 25 mm long. The dehiscence is characteristic of the subgenus *Vireya*, the soft exocarp first peeling off, after which the five valves separate at the summit and become recurved. The minute seeds bear at both ends appendages much longer than themselves.

This species is very close to *R. kochii;* it is not close to the *R. xanthopetalum* group, in whose neighborhood my artificial key, based on the pubescence of the floral parts, places it.

12. RHODODENDRON MINDANAENSE Merrill.

Rhododendron mindanaense MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 41; Philip. Journ. Sci. 3 (1908) Bot. 381; Enum. Philip. Fl. Pl. 3 (1923) 244; ELMER in Leafl. Philip. Bot. 3 (1911) 1106; MILLAIS, Rhodod. (1917) 210, 2d ser. (1924) 188.

The original description is as follows:

A shrub about 1 m. high, with glabrous, coriaceous, oblong-ovate obtuse leaves, the white flowers 4 to 4.5 cm. long, crowded in fascicles at the apices of the branches. Branches reddish or somewhat grayish, the ultimate branchlets sparingly lepidote. Leaves crowded at the upper nodes and at the apices of the branchlets, 5 to 7 cm. long, 2 to 3.5 cm. wide, tapering below to the cuneate base, the apex obtuse, often slightly emarginate, beneath with few scattered, obscure glands; petioles about 1 cm. long, sparingly lepidote. Flowers many, the peduncles 2 cm. long, lepidote, the deciduous bracts 2 to 3 cm. long. Calyx reduced to an obscure disk. Corolla 4 to 4.5 cm. long, narrowly campanulate, the tube 2.5 cm. long, 5 mm. in diameter below, very slightly enlarged above, the lim 3 to 3.5 cm. in diameter, 5-lobed, the lobes erect-spreading, obovate, obtuse, 2 cm. long. Stamens 10, the filaments pubescent below, glabrous above, 2.5 cm. long, the anthers 3 mm. long. Ovary densely yellowish brown pubescent, 6 mm. long. Style pubescent below, glabrous above, 2 cm. long.

Type specimen No. 1042 (Copeland), Mt. Apo, District of Davao, Mindanao, April, 1904; also No. 73 (De Vore and Hoover), same locality, May, 1903, erroneously localized as from the Island of Basilan. A shrub growing at the summit of the mountain at an altitude of 3,100 m. above the sea.

Specimens examined (representing all known collections): MINDANAO, Davao Province, Mount Apo, *Copeland 1042* (M), *Mearns s. n.* (W), *De Vore and Hoover 73* (M), *Elmer 11383* (M, W).

Elmer gives the following field notes:

A stunted erect shrub, 3 feet high, scattered with other dwarfed shrubs about the summit of mount Apo at 9,950 feet; stems erect, few to several, sparingly branched; leaves rigidly coriaceous, copiously arranged in subwhorls, ascending, paler green beneath; flowers pure white, rather large and showy, ascendingly scattered. The Bagobos call it "Malagus."

The fruits, numerous in each cluster, are massive, fusiform, slightly curved, warty and pilose, about 3.5 cm long, on stout pedicels of equal length. Each one has five lengthwise grooves. The dehiscence is probably exactly like that of *R. kochii.*

The species is fairly close to *R. kochii* and *R. teysmanni,* differing in the smaller stature and rounded leaves, and in the massiveness of the fruits and other parts. The anthers are minutely appendaged at the base.

13. RHODODENDRON BRACHYGYNUM sp. nov.

Frutex 1 m altus, floribus flavis. Rami in sicco fusco-rufi. Folia aut dispersa, aut in apicibus ramulorum congregata, ovalia, supra lucida, minutissime nigro-punctata, subtus modice pallide lepidota, ca. 10 cm longa, 4.5 cm lata, apice breviter acuminata, basi obtusa, in petiolum 1.5 cm longum decurrentia. Flores ca. quini in umbellis sessilibus. Pedicelli validi, pubescentes ca. 2 cm longi. Corolla flava, anguste obconica, ca. 4 cm longa; lobis 5, rotundis, ca. 1.5 cm longis. Stamina 10, filamentis ca. 3 cm longis, in parte inferiore minute pubescentibus; antheris oblongis, 3 mm longis, basi minute appendiculatis. Pistillum 1.6 mm longum, dimidio inferiore pubescente; ovario anguste conico, 8 mm longo; stigmate 2 mm lato. Gemmae fructusque ignoti.

CEBU, Sudlon, *For. Bur. 28346 Cenabre and De la Cruz* (M).

This species, known to me by a single specimen which was perhaps the only one collected, shows very interesting relationships. It is very close to *R. teysmanni* Miquel and to *R. kochii*. The leaves, which are very similar in all three species, are smaller in *R. kochii* than in the others. *Rhododendron brachygynum* differs from *R. kochii* in having yellow flowers; those of *R. teysmanni* are also yellow. The appendages on the anthers are shared by *R. teysmanni* and, if not by *R. kockii,* at least by its close relative *R. mindanaense*. On the other hand, this species represents a transition from the ones just mentioned to *R. leytense* and *R. loheri,* which share the yellow flowers and appendaged anthers, but have somewhat smaller leaves, not at all acuminate, and drying to a dark brown color. All the species here mentioned are alike in the pubescence on the ovary and filaments. *Rhododendron brachygynum* differs from all the others in the fact that the pistil is only about half as long as the stamens.

14. RHODODENDRON LEYTENSE Merrill.

Rhododendron leytense MERRILL in Philip. Journ. Sci. 10 (1915) Bot. 55; Enum. Philip. Fl. Pl. 3 (1923) 244.

The original description is as follows:

Frutex epiphyticus, subglaber, ramis ramulisque teretibus; foliis coriaceis, alternis vel subverticillatis, oblongis vel oblongo-ellipticis, usque ad 7 cm longis, utrinque angustatis acutisque, supra nitidis, subtus lepidotis, nervis lateralibus utrinque circiter 8, tenuibus, obscuris; floribus terminalibus, in umbellis sessilibus dispositis, bracteis involucrantibus caducis, oblongis, acuminatis, circiter 2.5 cm longis; corolla flava, 4 cm longa, late tubuloso-campanulata.

An epiphytic, nearly glabrous shrub, the branches and branchlets terete, grayish or reddish-brown, smooth, the ultimate ones about 2.5 mm in diameter. Leaves alternate or subverticillate, coriaceous, oblong to oblong-elliptic, 4 to 7 cm long, 1.5 to 3 cm wide, subequally narrowed to both the acute base and apex, or the base sometimes a little decurrent-acuminate, brownish when dry, the upper surface glabrous, shining, the lower somewhat paler, and with numerous, but not densely arranged, brown lepidote scales; lateral nerves slender, obscure, about 8 on each side of the midrib; petioles 1 to 1.5 cm long. Inflorescence terminal, the flowers in sessile umbels, in bud quite enclosed by imbricate bracts, the bracts caducous, brown when dry, glabrous, shining, oblong, acuminate, about 2.5 cm long, the bracteoles narrow. Flowers yellow, usually 4 or 5 in each umbel, their pedicels pubescent, about 1 cm long in anthesis, twice as long in young fruit. Calyx obsolete, represented by a mere thickening of the apex of the pedicel. Corolla broadly tubular-campanulate, yellow, about 4 cm long, the tube broad, about 2 cm long, the lobes broadly elliptic to obovate, rounded, 1.3 to 1.5 cm wide. Stamens 9 or 10, the filaments slender, a little unequal; anthers oblong, obtuse, 3 mm long. Ovary rather densely pubescent, cylindric, elongated, narrowed upward into the style which is pubescent below and glabrous above; stigma with 5, stout, broad, obtuse lobes.

LEYTE, Mount Ibuni, back of Dagami, *Bur. Sci. 15252 Ramos*, August 23, 1912, growing in the tops of trees.

A rather characteristic species, among the Philippine forms perhaps most closely allied to *Rhododendron kochii* Stein, although entirely different from that species in many details of its leaves, and in the color and character of its flowers.

The stamens are sparsely pubescent near the base.

This species is known only by the type collection. I have seen the specimens of the herbarium of the Bureau of Science at Manila, and of the United States National Herbarium.

15. RHODODENDRON LOHERI sp. nov.

Arbustus, floribus pallide flavis. Folia ovalia, 4 ad 8 cm longa, superne nuda, rugulosa, subtus modice lepidota, apice obtusa, basi obtusa, in petiolum 1 cm longum decurrentia. Flores ca. quini in umbellis terminalibus. Pedicelli crassi, puberulentes, 2 ad 3 cm longi. Calyx disciformis. Corolla anguste obconica, circa 3 cm longa, pallide flava, minus quam 1 cm longa. Stamina 10, filamentis ca. 2 cm longis, in parte infima minute pubescentibus, antheribus ca. 2.5 cm longis, basi minute appendiculatis. Pistillum ca. 2.5 cm longum, dimidio inferiore pubescente; ovario anguste conico, 10 mm longo; stigmate 2.5 mm lato. Gemmae fructusque inogti.

LUZON, Rizal Province, Guinuisan, *Loher 14769* (M, C).

This species, known by a single collection from the poorly explored mountainous region some distance east of Manila, is very close to *R. leytense;* the leaves, which are broadly elliptic, brown when dry, and besprinkled on the lower surface with

pale scales, are indistinguishable from those of Merrill's species. The separation is based on the slightly smaller corolla, which is of firmer texture; the smaller pistil, which equals the stamens; and the minute appendages at the base of the pollen sacs.

The relationships of the Philippine *Euvireyas* have, I think, been sufficiently discussed under *R. brachygynum*. With them, and with *R. javanicum* (Blume) Bennett and *R. teysmanni* Miquel, both of which occur in the Malay Peninsula and Archipelago, one associates the Bornean *R. kinabaluense* Merrill and *R. obscurinervium* Merrill and the New Guinean *R. zoelleri* Warburg.

Subsection 5. LEOIVIREYA

Epiphytes; leaves leathery to fleshy, usually not acuminate; flowers large, usually colored; the filaments usually pubescent, the anthers large, linear, without appendages; ovary glabrous to moderately lepidote; style columnar, stigma capitate. The type is *R. crassifolium* Stapf.

16. RHODODENDRON CLEMENTIS Merrill.

Rhododendron clementis MERRILL in Philip. Journ. Sci. 3 (1908) Bot. 160, 381; Enum. Philip. Fl. Pl. 3 (1923) 243; MILLAIS, Rhodod. 2d ser. (1924) 113.

The original description is as follows:

Arbor glabra; foliis subcoriaceis, elliptico-oblongis, obtusis, usque ad 16 cm longis, nitidis, subtus squamulis parvis notatis; floribus aurantiacis, 4.5 ad 5 cm longis latisque, glabris; staminibus 10, in parte inferiore plus minus pubescentibus; ovario oblongo, glabro, 5-loculari.

A tree, the branches terete, reddish-brown or grayish, the younger ones dark-reddish-brown, glabrous. Leaves elliptical-oblong, 9 to 16 cm long, 4.5 to 8 cm wide, subcoriaceous, shining, somewhat paler beneath, entirely glabrous above, beneath with numerous scattered small lepidote glands, the base acute, the apex usually broad, rounded, rarely subacute or obscurely acuminate; nerves about 10 on each side of the midrib, not prominent, somewhat ascending, reticulating; petioles stout, 1 to 1.5 cm long. Flowers orange-colored, 5 to 10 or more at the apices of the branches on a short stout rachis, the buds covered by numerous membranous, shining, deciduous, elliptical bracts about 3 cm long, forming ellipsoid heads 3 to 3.5 cm long; pedicels glabrous, 2 to 3 cm long. Calyx disciform, 5-toothed. Corolla glabrous, 4.5 to 5 cm long and wide, the tube about 2 cm long, somewhat broadened upwards, the lobes 2.5 cm long, 2 cm wide, elliptical-obovate, rounded. Stamens 10; filaments 2.5 to 2.8 cm long, more or less pilose below, glabrous above; anthers 5.5 to 7 mm long. Ovary oblong, glabrous, 5 mm long, 5-celled; style glabrous, 1 cm long; stigma capitate, 2 mm in diameter. Immature fruit glabrous.

MINDANAO, Lake Lanao, Camp Keithley, *Mrs. Clemens 732*, October, 1906, also without numbers, November, 1906, and October, 1907.

A species characterized by its orange flowers, oblong-elliptical obtuse leaves, which are but slightly lepidote beneath, its glabrous ovaries, etc.

MINDANAO, Lanao Province, Camp Keithley, *Clemens 732* (M, W), also several unnumbered sheets; Camp Vicars, *For. Bur. 25221 Alvarez?*, in fruit (M, W): Zamboanga Province, Sax River Mountains, *Merrill 8136* (M). JOLO, *Clemens 9398, 9399* (M).

Rhododendron clementis is no tree, but an epiphyte. Under this name are included specimens with strictly glabrous, rather bulky, ovaries, the basal disk and calyx being but slightly wider than the ovary, the disk crowned with white hairs. The corolla is orange in the type material and in the specimens from Jolo, which differ only in that all parts, leaves, buds, and flowers, are larger. Alvarez's specimen, from Lanao, in fruit, has narrow leaves, and may, very likely, be referable to *R. spectabile*. *Merrill 8136* has red flowers, and seems to be intermediate between this species and *R. spectabile*.

17. RHODODENDRON SPECTABILE Merrill.

Rhododendron spectabile MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 42; Philip. Journ. Sci. 3 (1908) Bot. 381; Enum. Philip. Fl. Pl. 3 (1923) 245; ELMER in Leafl. Philip. Bot. 3 (1911) 1106; MILLAIS, Rhodod. (1917) 246, 2d ser. (1925) 241.

The original description reads as follows:

A glabrous shrub about 1 m. high, with coriaceous, elliptical-ovate to elliptical-oblong, scattered, alternate, acuminate or merely acute leaves, and large, red odorless flowers, 5 to 5.5 cm. long, in terminal 3-flowered fascicles. Branches glabrous, the ultimate ones reddish brown. Leaves 7 to 9 cm. long, 3.5 to 4.5 cm. wide, glabrous above, glandular-punctate beneath, the base acute or somewhat rounded, the midrib very prominent; petioles very stout, 1 to 1.5 cm. long. Peduncles glabrous, 2.5 cm. long. Calyx reduced to an obscure disk. Corolla campanulate, the tube 2 cm. long, 6 mm. in diameter below, the limb spreading, 5 to 6 cm. in diameter, 5-lobed, the lobes 2.5 cm. long, elliptical-ovate, rounded. Stamens 10, the filaments sparingly pubescent below, 2.5 cm. long, the anthers 5 mm. long. Ovary glabrous, oblong, 8 mm. long; style glabrous, 2.5 cm. long.

Type specimen No. 1438 (Copeland), Mount Apo, District of Davao, Mindanao, October, 1904; also No. 369 (in part) (De Vore and Hoover), same locality, May, 1908. A shrub growing in ravines at an altitude of 2,500 m., apparently closely related to *Rhododendron javanicum* Blume.

MINDANAO, Davao Province, Mount Apo, *Copeland 1438* (M, W), *De Vore and Hoover 369* (M), *Mearns*, three unnumbered sheets (W), *Elmer 10631* (W). CAMIGUIN DE MISAMIS, Camiguin Volcano, *Bur. Sci. 14599 Ramos* (M).

Elmer's field note on this species reads as follows:

An epiphyte in moss covered dry woods on a ridge 7,500 feet of mount Calelan; stems few, spreading, subdeflexed, the tips suberect and green; twigs rather gnarly, ashy gray; leaves thickly coriaceous, dull dark green on the upper side, gradually recurved, much lighter green and punctate

beneath; flowers divaricate, not numerously clustered, very showy, odorless, pedicels thick, terete, ascending, reddish; corolla heavy and somewhat fleshy, 2 to 3 inches long, purple red, the rotate lobes as widely spreading as the flower is long; stamens and pistil pale red; ovary glabrous, reddish brown; anthers creamy yellow. "Malagas" is the native Bagobo name.

Represented by number 10631, *Elmer*, Todaya (mt. Apo), Mindanao, May, 1909.

To this species are assigned specimens with rather narrow leaves scattered along the branches. The flowers are red, large, few in the cluster; the ovary is rather slender, the disk almost glabrous, the calyx about twice as broad as the base of the ovary.

Field notes are scarce. The type was apparently a terrestrial plant. Mearns's specimens (two of them apparently from the same plant) have rather longer leaves than the type. Elmer's specimen has decidedly broader leaves than the type, and was an epiphyte; as the above-quoted note shows, it was not from Apo proper, but from the neighboring Mount Calelan. The specimen from Camiguin de Misamis is geographically incongruous. It has smaller flowers than the type, and they are described as "rose champaca," which probably means brownish pink; nevertheless the specimen appears to belong to this species.

18. **RHODODENDRON XANTHOPETALUM Merrill.**

Rhododendron xanthopetalum MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 41; Philip. Journ. Sci. 1 (1906) Suppl. 111, 3 (1908) Bot. 380; Enum. Philip. Fl. Pl. 3 (1923) 246; MILLAIS, Rhodod. (1917) 263, 2d ser. (1924) 261.

The original description reads as follows:

A glabrous epiphytic shrub, 80 cm. or less high, with a stout, simple or but slightly branched stem, coriaceous, scattered, alternate, slightly acuminate or merely acute, oblong-elliptical leaves, the flowers yellow, 3 cm. long, 3 or 4 in a terminal fascicle. Stem 1 cm. in diameter below, the bark light gray, glabrous, the younger parts reddish brown. Leaves 9 to 12 cm. long, 3.5 to 5 cm. wide, the base acute, the upper surface glabrous, the lower surface somewhat paler, glandular-punctate, the margins revolute, the midrib very stout and prominent; petioles very stout, 1.5 cm long. Peduncles glabrous, 1.5 cm. long. Calyx reduced to an obscure disk. Corolla 5-lobed, campanulate, 3 to 3.4 cm. long and about as wide, the tube 1.5 cm. long, 5 mm. in diameter below, the lobes 1.5 cm. long, rounded. Stamens 10, the filaments pubescent bellow, 18 mm. long, the anthers 4 mm long. Ovary 8 mm. long, lepidote, 5-celled style 12 mm. long, glabrous.

Type specimen No. 322 (Whitford), Mount Mariveles, Province of Bataan, Luzon, May, 1904. A small shrub growing on mossy tree trunks at an altitude of 1,200 m. Apparently rare, as only a single specimen was found.

LUZON, Bataan Province, Mount Mariveles, *Whitford 322* (M), *For. Bur. 6279 Curran* (M): Rizal Province, Montalban,

Loher s. n. (C): Nueva Vizcaya Province, Carballo Sur Mountains, *Loher, s. n.* (C) MINDORO, Ibolo, *For. Bur. 11429 Merritt.*

This species remains "apparently rare." It is definitely marked by the rather small lepidote ovary, which is totally without pubescence, although a few hairs occur on top of the disk which surrounds the base of the ovary. The calyx is much broader than the base of the ovary. I have little confidence in the identification of the specimen from Mindoro; it is in poor condition, and might better, perhaps, be assigned to *R. clementis.*

19. **RHODODENDRON SCHADENBERGII Warburg.**

Rhododendron schadenbergii WARBURG in Perkins Frag. Fl. Philip. (1905) 172; MERRILL in Philip. Journ. Sci. 3 (1908) Bot. 380, in part; MILLAIS, Rhodod. (1917) 239, 2d ser. (1924) 230.

The original description is as follows:

Ramis teretibus glabris, petiolis crassis foliis crasse coriaceis oblongis basi et apice acutis supra glabris subtus squamulis inspersis, venis utrinque 6–12 semipatentibus apice curvatis supra prominulis subtus vix distinctis, interspersis interdum minoribus subparallelis, nervis tertiariis haud vel vix perspicuis. Inflorescentia terminali, pedunculo brevissimo valdo crasso bractearum cicatricibus obtecto, pedicellis subumbellate dispositis longis quam flores brevioribus glabris, apice bracteolam membranaceam glabram lanceolatam vel lineari-lanceolatam gerentibus, calyce disciformi 5-angulato, disco annuliformi 10-nodoso, corolla glabra infundibuliformi campanulata ad medium fere 5-lobata, lobis apice rotundatis haud emarginatis, staminibus 10 filamentis in parte superiore pilosis, antheris magnis crassis oblongis, ovario glabro oblongo, stylo crasso quam ovarium longiore apice disco lato stigmatifero capitato.

Die Blattstiele sind 1½ cm lang, 3 mm dick, die Blätter sind 8–11 cm lang, 2½–4 cm breit, die grösste Breite liegt in der Mitte, von wo sie sich nach beiden Seiten hin langsam verschmälern, nach der Basis zu langsam in der Blattstiel auslaufend, oberseits eine nicht abgespitzte Spitze bildend. Die gemeinsame Blütenstandstiel ist 8 mm lang und 10 mm breit, die einzelnen Bracteennarben sind 1 mm hoch und 8 mm breit, die Blütonstielchen sind 2½ cm lang, 1½ mm dick, die Bracteole an der Spitze derselben ist ½–1½ cm lang, und unten ca. 2 mm breit, der fünfeckige Kelch ist 5 mm breit und hat eine Höhe von 1 mm, die Corolla ist 3½–4 cm lang, die einzelnen Lappen derselben sind 1½–2 cm lang und fast ebenso breit, die Stanbgefässe sind 2½ cm lang, am unteren ende fast 1 mm breit, grau behaart; die Antheren sind 4 mm lang, 1¼–1½ mm breit; das Ovar ist 8–10 mm lang, 3½ mm breit, der Griffel ist 12–15 mm lang, ¾–1 mm breit, kahl, und entweitert sich oben zu einer 3 mm breiten Scheibe.

LUZON Isl., Prov. Abra, 1300 m. s. m. (SCHADENBERG).

Diese sehr schöne neue Art, deren Farbe leider in dem mir von dem Sammler freundigst mittgeteilten Alkoholmaterial nicht mehr erkennbar war, steht dem *Rh. javanicum* und *Teysmanni* am nächsten, die dickere lederartige Konsistenz der nicht zugespitzten unten zerstreut mit Schuppen besetzten Blätter das viel grösser ganz kahle Ovar, der dickere kahle Griffel, die längeren Antheren sind die Hauptunterchiede.

I regard the following specimens as representative:

LUZON, Mountain Province, Bontoc Subprovince, Tinglayan, *For. Bur. 10989 Curran* (M, W): Ifugao Subprovince, Mount Polis, *Bur. Sci. 19654 McGregor* (M).

Ignorance of the color of the flowers delayed the recognition of this species for more than twenty years. With regard to the type of *R. schadenbergii,* Merrill [8] remarks:

The type, which I have seen in the Berlin Herbarium, is in very poor condition, having been dried out from alcoholic material, and consequently much shriveled, so that an examination of it was very unsatisfactory: consequently my conception of the species has been based largely on the elaborate original description . . . Most of the specimens previously referred by me to this species are, I believe, referable to *Rhododendron kochii* Stein.

Under these conditions Merrill took *Williams 990* and *1348,* and *Elmer 6519,* (typical of *R. williamsii,* published above) as representing Warburg's species. The following table compares the original description with *R. williamsii* and with the specimens cited above:

	R. schadenbergii (original description).	*Williams 990, 1348; Elmer 6519.*	*For. Bur. 10989 Curran; B. S. 19654 McGregor.*
Petioles ..... mm	1.5 by 3	15–20 by 1–3	8–17 by 3–4.
Leaves, size ... do	80–110 by 25–40	80–110 by 30–60	8–12 by 3–5.
Leaves, shape	Oblong, acute at both ends; decurrent at base; sharp, not acuminate.	Oval; base blunt, decurrent; apex acuminate!	Oval to elliptic, base blunt, scarcely decurrent; apex acute, usually not acuminate.
Veins on each side of the midrib.	6–12	6–12	6–12.
Surface	Glabrous above, sparsely lepidote beneath.	Glabrous above, sparsely lepidote beneath.	Glabrous above, sparsely lepidote beneath.
Texture	"Crasse coriaceis;" "dickere lederartige."	Herbaceous	Thick, fleshy.
Peduncle ..... mm	8 by 11	10 by 4	7–15 by 7–10.
Bract scars ... do	1 by 8	1 by 4	1 by 8.
Pedicels	Shorter than the flowers; 25 mm long; fleshy; glabrous.	Equaling the flowers; 25–30 mm long; woody; lepidote.	Shorter than the flowers; 20 mm long; fleshy; glabrous.
Calyx, width ... do	5	5	5.
Corolla, length ... cm	3.5–4	2–4	3–4.5.
Corolla, lobes, length do	1.5–2	1–1.5	1.5–2.
Filaments	2.5 cm long, gray hairy (above?)	2.3 cm long, glabrous!	2.5 cm long, gray hairy at base!
Ovary	8–10 mm long, glabrous	8–10 mm long, lepidote.	8 mm long, glabrous.
Style, length ... mm	12–15	20	12–16.
Stigma, diameter do	3	3	4.

[8] Philip. Journ. Sci. 3 (1908) Bot. 380.

Curran's collection and McGregor's appear to agree with Warburg's description in every significant respect except for the position of the pubescence on the filaments. However, "filamentis in parte superiore pilosis" describes no known Philippine *Rhododendron*, and I take the statement to be an error.

The plant is a small woody shrub with showy salmon-pink flowers. It belongs in the circle of relationship of *Rhododendron xanthopetalum*, having colored flowers, the ovary quite without hairiness, and the filaments hairy in the lower part. It is distinguished from its close relatives by the peculiar shade of the flowers and by the massive ovary and short style, which, with the disk, are totally devoid of hairs or scales. It is apparently quite rare, since the continual botanical activity in the Philippines in the past twenty years has brought in only two valid collections.

20. **RHODODENDRON LOBOENSE** sp. nov.

Fruticulus epiphyticus 30 ad 40 cm altus, foliis crassis, floribus flavis, magnitudinis mediocris, stricte glabris. Rami glabri, rugulosi, griseo-brunnei, minus quam 1 cm in diametro. Folia dispersa, in senectute recurvia, crassa, elliptica, basi et apice obtusa, 11 ad 12 cm longa, 5 ad 6 cm lata; marginibus leviter recurvis; venis utrinque ca. 15, apertis; petiolis crassis, 1 ad 1.5 cm longis. Gemmae ignotae. Flores ca. quini in umbellis sessilibus; pedicellis validis, 1 ad 1.5 cm longis. Calyx vix evidente. Discus prominens, 10-lobatus, stricte glaber, quam ovario duplo latiore. Corolla flava, intus et extus glabra, 3.5 ad 4 cm longa, lobis 5 inaequalibus, ovalibus, ca. 2 cm longis. Stamina 10, filamentis stricte glabris, 2.5 cm longis; antheris oblongis, 4 mm longis. Pistillum 2 cm longum, glabrum, ovario elliptico, 7 mm longo, stigmate 3 mm lato. Fructus 4 cm longus, pedicello 1.5 ad 2 cm longo, valvis 5 in dehiscentia recurvis. Semina fulva, fusiformia, minus quam 1 mm longa, utrinque appendiculata; appendiculis filiformibus, 3 mm longis.

LUZON, Batangas Province, Lobo Mountains, *For. Bur. 28045 Mabesa* (M).

This species, known by a single specimen, is characterized by the strictly glabrous flower parts. The colored flowers, thick leaves, and bulky ovaries lead me to list it with the relatives of *R. clementis*, and not close to *R. williamsii*, which shares the nakedness of ovary, disk, and filaments.

The above five species constitute a very natural group, especially well developed in Borneo; *R. crassifolium* Stapf, of British

North Borneo, has the same fleshy leaves and glabrous ovaries, but the flowers are white or pink. Other related species are *R. brevitubum* J. J. Smith, *R. crassinervium* Ridley, *R. moultonii* Ridley, and *R. murudense* Merrill. *Rhododendron brookeanum* Low and *R. lowii* Hooker f. are also very similar, but have pubescent ovaries; they appear to represent the evolutionary transition from section *Euvireya.* I have taken *R. clementis* as the most primitive of the Philippine species because it extends nearest to Borneo, and because it retains slightly more pubescence about the ovary than the others.

J. J. Smith [9] concludes his discussion of the relationships of *R. brevitubum* with the remark: "Vielleicht werden mehrere dieser Arten bei Vergleichung von nehr Material sich nur als Varietäten erweisen." This applies to the Philippine species. They are variable and they intergrade; they are collected but rarely, and almost every collection presents distinguishing characters. The distinctions lie, however, in minor details; I have been loathe to describe new species and have listed three described by Merrill together with the previously incorrectly recognized *R. schadenbergii* and one new species which is sufficiently distinguishable.

Subgenus ANTHODENDRON Endlicher

This is the group of the azaleas, for which Wilson and Rehder, in their recent Monograph of Azaleas, have shown that it is necessary to accept Endlicher's name. It is a natural group, originally distinguished from *Rhododendron* proper by deciduous foliage and flowers with five stamens instead of ten. It is a large group (with 51 species listed by Wilson and Rehder) and widely distributed; as at present limited it is very hard to define by description. Of the four sections into which Wilson and Rehder divide it, only one is represented in the Philippines.

Section TSUSUTSI G. Don

Shoots beset with flattened reddish hairs, occasionally also with spreading soft hairs. Stamens 5 or 10. Ovary beset with hairs similar to those on the foliage, sometimes glandular. Fruit conical, the valves in dehiscence separating slightly at the apex. Seeds without appendages. There are 22 species, all in eastern Asia.

[9] Ic. Bogor. 4 (1914) 253–254.

21. RHODODENDRON SUBSESSILE Rendle.

Rhododendron subsessile RENDLE in Journ. Bot. 34 (1896) 357; MERRILL in Govt. Lab. Publ. (Philip.) 29 (1905) 40; Philip. Journ. Sci. 3 (1908) Bot. 379, 5 (1910) Bot. 371; Enum. Philip. Fl. Pl. 3 (1923) 245; MILLAIS, Rhodod. (1917) 249, 2d ser. (1924) 244; WILSON and REHDER, Monograph of Azaleas (1921) 51.

Rendle's original description reads as follows:

Lignosus, ramis teretibus cum setulis brunneis apressis indutis; follis ovalibus, apice abrupte breviter et obtuse mucronatis, petiolis et facie inferiore laminæ, præcipue in venis, brunne setuliferis, facie superiore cum setulis albis induta; bracteis læte brunneis ovatis vel orbiculari-ovatis, mucronatis, flore solitario subsessile, inter minores; calyce lobis 5 subrotundis fimbriatis; corolla rosea late infundibuliforme, tubo sub-brevi lato, lobis ovatis vel ovato-oblongis, staminum filamentis in parte inferiore breviter pilosis, superne glabris; ovario 5-loculare subrotundo dense piloso, stylo flexuoso basi piloso.

Hab. North-west-central Luzon, highland of Lepanto.

The younger shoots are covered with closely-packed upwardly-directed appressed brownish bristles, which in the third season are wearing off; the shoots of the third season are 3 mm. in diameter. The leaves, which are scattered along the shoot, vary in length of lamina from 2 to 4 cm., and in breadth from 6 to 14 mm.; the petiole is from 3 to 6 mm. long. The broad bracts are 8–9 mm. long; the hairy pedical 4 mm., the calyx lobes 2–3 mm. The broad corolla-tube is 9 mm. long, 5 mm. in diameter below, and only slightly more above; the lobes are 12 mm. long, 8–9 mm. broad. The short ovary (3 mm. long) is densely covered with shiny reddish upwardly directed hairs; the uniform style is 2 cm. long, ending in a small capitate stigma.

Is near *R. ledifolium* G. Don, but is, I think, distinct; the solitary almost sessile flower is much smaller than in the Chinese-Japanese species.

LUZON, Mountain Province, Benguet Subprovince, Mount Data, fragment of the type in Herb. Mus. Brit. *Whitehead s. n.* (M), *Merrill 4606* (M, W); Mount Tonglon or Santo Tomas, *For. Bur. 922 Barnes* (M, W), *Williams, 1223, 2001* (M, W), *Elmer 5799* (M, W), *Bur. Sci. 4815 Merrill* (M, W), *For. Bur. 5032 Curran* (M), *Mearns s. n.* (M), *For. Bur. 14168 Merritt* (M), *For. Bur. 11090 Whitford* (M), *Merrill 736* (M, W), *For. Bur. 25125 Leaño* (M, W), *Clemens 4966* (C), *Bur. Sci. 15775 Clemens* (C), *Bur. Sci. 45099 Ramos and Edaño* (M, C), *Bur. Sci. 16008 McClure* (C); *Elmer 8595, 14298* (M, W), *Santos 38* (M); Pauai, or Haight's, and neighborhood, *Bur. Sci. 4690 Merrill* (M, W), *Bur. Sci. 4275 Mearns* (M), *Bur. Sci. 8420 McGregor* (M), *Bur. Sci. 13994 Santos* (M), Mount Pulog, *For. Bur. 18035 Curran et al.* (M, W), *For. Bur. 18172 Curran et al.* (M), *Clemens 5063* (C), Banguino (?), *Loher 3758* (M); Mount Bau-

dan, *Bur. Sci. 40308 Ramos and Edaño* (M, W) ; Bucao, *For. Bur. 18362 Alvarez* (M) : Ifugao Subprovince, Mount Polis, *Bur. Sci. 37708 Ramos and Edaño* (M) : Lepanto Subprovince, Banaao, *Vanoverbergh 364* (M) ; Mount Malaya, *For. Bur. 16573 Darling* (M) : Bontoc Subprovince, *Clemens 7278* (C) : Abra Province, Mount Paraga, *Bur. Sci. 7105, 7249 Ramos* (M), "Central Luzon," *Loher 3760* (W).

This is the most southerly occurring, and the only Philippine, representative of the subgenus *Anthodendron.* It belongs to the northern element in the flora of Luzon, and its nearest relatives are to be found in Formosa; it is not related to the other Philippine species of *Rhododendron,* all of which have come from the south.

From the other Philippine rhododendrons it is sharply distinguished by the subgeneric and sectional characters. The stamens bear, near the base, a few very short, blunt, unicellular, white trichomes; this character also is shared by other species of *Anthodendron.* As a typical *Anthodendron, R. subsessile* is a terrestrial shrub, commonly 1 to 3 m high, but reaching a height of 6 m, occurring in clumps or masses. It occurs in the mountains from elevations of about 1,800 m up to summits about 2,400 m high. The flowers are described on fields notes as white, pink, red, violet, or purple; they have been collected in almost every month of the year. These flowers are more often in clusters of two or three than solitary. The pedicels are not consistently as short as the original description would indicate.

From *R. mucronatum* G. Don (*R. ledifolium* G. Don), with which Rendle compares it, and from *R. oldhamii* Maximowicz, a Formosan species with which Merrill compares it, Wilson distinguishes this species by the facts that the bud scales are not viscid within; that the calyx lobes are minute; and that the style bears, at the very base, a pubescence similar to that on the leaves, bud scales, and ovary. From *R. lasiostylum* Hayata and from *R. rubropilosum* Hayata, Wilson distinguishes it only by the shape of the leaves and the color of the flowers; the latter is certainly too inconstant to be distinctive.

Var. BAUCOENSE var. nov.

Suffrutex; foliis 4 ad 15 mm longis, 2 ad 5 mm latis; floribus rubris, minus quam in species.

LUZON, Mountain Province, Lepanto Subprovince, Bauko, *Vanoverbergh 351* (M), April, 1910.

Wilson comments on this specimen as follows:

> No. 351, also from Bontoc, has very slender branches and small, elliptic, acute leaves and is very different in appearance from the other specimens. I can find no morphological differences, and it appears to be simply a condition; probably the plant from which the specimen was taken was growing in the crevice of a boulder or of a cliff.

I am rather inclined to suspect that the species bears toward this variety the relation of a gigas form. The possibility of this relationship will explain not only the specimen on which this variety is based, but also several similarly anomalous specimens of other species.

ILLUSTRATIONS

PLATE 1

FIGS. 1 and 2. *Rhododendron quadrasianum*, tpyical, *Robinson 6502*, leaves, natural size.
FIG. 3. *Forma marivelesense, Merrill 3215*, leaf, natural size.
4. Forma *marivelesense, Merrill 3215*, flower, × 2.
5. Forma *halconense, Merrill 5736*, leaf, natural size.
6. Forma *negrosense, Elmer 9738*, leaf, natural size.
FIGS. 7 and 8. *Var. malindangense, For. Bur. 4705 Mearns and Hutchinson*, leaves, natural size.
FIG. 9. Forma *davaoense, Williams 2543*, leaf, natural size.
10. Forma *davaoense, Williams 2543*, flower, × 2.
FIGS. 11 and 12. Var. *intermedium, For. Bur. 8063 Curran and Merritt*, leaves, natural size.
13, 14, and 15. Var. *rosmarinifolium, Elmer 14285*, leaves, natural size.
16 and 17. Var. *rosmarinifolium, Elmer 5798*, leaves, natural size.
FIG. 18. Var. *rosmarinifolium, Elmer 5798*, flower, × 2.
FIGS. 19 and 20. Forma *pulogense, Bur. Sci. 19736 McGregor*, leaves, natural size.
FIG. 21. Forma *pulogense, Bur. Sci. 19736 McGregor*, flower, × 2.
22. Forma *pulogense, Clemens 16394*, flower, × 2.
23. Forma *pulogense, Clemens 16394*, Stamen, × 5.
24. Forma *banahaoense, Bur. Sci. 19588 Ramos*, leaf, natural size.
FIGS. 25 and 26. Forma *marivelesense, Merrill 3215*, anthers, × 10.
FIG. 27. Forma *marivelesense, Loher 12418*, pistil, × 5.
28. Forma *pulogense*, fruit, × 2.
29. Forma *intermedium*, fruit, × 2.
30. *Rhododendron apoanum*, flower, × 2.
31. *Rhododendron apoanum*, stamen, × 5.
32. *Rhododendron apoanum*, anther, × 10.

PLATE 2

FIG. 1. *Rhododendron apoanum*, pistil, × 5.
2. *Rhododendron nortoniae*, two umbels of type, natural size.
3. *Rhododendron nortoniae*, stamen, × 2.
4. *Rhododendron nortoniae*, pistil, × 2.
5. *Rhododendron catanduanense*, two leaves of type, natural size.
6. *Rhododendron catanduanense*, fruit, natural size.

PLATE 3

Rhododendron nortoniae, foliage of type, natural size.

PLATE 4

FIG. 1. *Rhododendron bagobonum*, foliage and flower of type, natural size.
2. *Rhododendron bagobonum*, fruit, × 2.
3. *Rhododendron vidalii*, *Bur. Sci. 37983 Ramos and Edaño*, stamen, × 2.
4. *Rhododendron vidalii*, anther, × 5.
5. *Rhododendron whiteheadi*, leaf of type, natural size.
6. *Rhododendron whiteheadi*, *For. Bur. 15783 Curran and Merritt*, leaf, natural size.

FIGS. 7 and 8. *Rhododendron whiteheadi*, *For. Bur. 8061 Curran and Merritt*, leaves, natural size.

FIG. 9. *Rhododendron whiteheadi*, *Bur. Sci. 4988 Ramos and Edaño*, pistil, × 2.5.
10. *Rhododendron whiteheadi*, stamen, × 5.
11. *Rhododendron whiteheadi*, anther, × 5.

PLATE 5

Rhododendron vidalii, *Bur. Sci. 37983 Ramos and Edaño*, foliage and flowers, natural size.

PLATE 6

FIG. 1. *Rhododendron taxifolium*, foliage and flowers of cotype, natural size.
2. *Rhododendron taxifolium*, leaf, × 5.
3. *Rhododendron taxifolium*, stamen, × 5.
4. *Rhododendron taxifolium*, anther, × 10.
5. *Rhododendron taxifolium*, pistil, × 10.
6. *Rhododendron taxifolium*, fruit, × 2.

PLATE 7

FIG. 1. *Rhododendron copelandi*, *Elmer 11395*, foliage and flowers, natural size.
2. *Rhododendron copelandi*, *Williams 2681*, stamen, × 2.

FIGS. 3 and 4. *Rhododendron copelandi*, anthers, × 10.

FIG. 5. *Rhododendron copelandi*, *De Vore and Hoover 242*, pistil, × 2.
6. *Rhododendron kochii*, stamen, × 2.
7. *Rhododendron kochii*, pistil, × 2.
8. *Rhododendron williamsii*, stamen, × 2.
9. *Rhododendron williamsii*, pistil, × 2.
10. *Rhododendron mindanaense*, *Mearns*, stamen, × 2.5.
11. *Rhododendron mindanaense*, anther, × 5.
12. *Rhododendron mindanaense*, pistil of type, × 2.5.

PLATE 8

Rhododendron kochii, foliage and flowers, natural size.

PLATE 9

Rhododendron williamsii, foliage and flowers, natural size.

PLATE 10

Rhododendron mindanaense, *Mearns*, foliage and flowers, natural size.

PLATE 11

FIG. 1. *Rhododendron kochii*, fruit, × 2.
2. *Rhododendron williamsii*, fruit, × 2.
3. *Rhododendron mindanaense, Elmer 11383*, fruit, natural size.
4. *Rhododendron brachygynum*, stamen of type, × 2.
5. *Rhododendron brachygynum*, anther, × 10.
6. *Rhododendron brachygynum*, pistil, × 2.
7. *Rhododendron leytense*, stamen of type, × 2.
8. *Rhododendron leytense*, anther, × 10.
9. *Rhododendron leytense*, pistil, × 2.
10. *Rhododendron loheri*, stamen of type, × 2.
11. *Rhododendron loheri*, anther, × 10.
12. *Rhododendron loheri*, pistil, × 2.

PLATE 12

FIGS. 1 and 2. *Rhododendron clementis*, leaves of cotype, natural size.
FIG. 3. *Rhododendron clementis*, stamen, × 2.
4. *Rhododendron clementis*, pistil, × 2.
5. *Rhododendron clementis, Bur. Sci. 9399 Clemens*, stamen, × 2.
6. *Rhododendron clementis, Bur. Sci. 9399 Clemens*, pistil, × 2.

PLATE 13

FIG. 1. *Rhododendron clementis, Merrill 3186*, leaf, natural size.
2. *Rhododendron clementis, Merrill 3186*, stamen, × 2.
3. *Rhododendron clementis, Merrill 3186*, pistil, × 2.
4. *Rhododendron spectabile*, stamen of type, × 2.
5. *Rhododendron spectabile*, pistil, × 2.

PLATE 14

Rhododendron spectabile, Mearns, foliage and flowers, natural size.

PLATE 15

FIG. 1. *Rhododendron xanthopetalum*, leaf of type, natural size.
2. *Rhododendron schadenbergii, Bur. Sci. 19654 McGregor*, leaf, natural size.
3. *Rhododendron loboense*, leaf of type, natural size.

PLATE 16

FIG. 1. *Rhododendron xanthopetalum*, stamen of type, × 2.
2. *Rhododendron xanthopetalum*, pistil, × 2.
3. *Rhododendron schadenbergii, Bur. Sci. 19654 McGregor*, stamen, × 2.
4. *Rhododendron schadenbergii, Bur. Sci. 19654 McGregor*, pistil, × 2.
5. *Rhododendron loboense*, stamen of type, × 2.
6. *Rhododendron loboense*, pistil, × 2.
7. *Rhododendron subsessile*, flower, × 2.
8. *Rhododendron subsessile*, anthers, × 10.
9. *Rhododendron subsessile*, pistil, × 2.
10. *Rhododendron subsessile*, fruit, × 2.

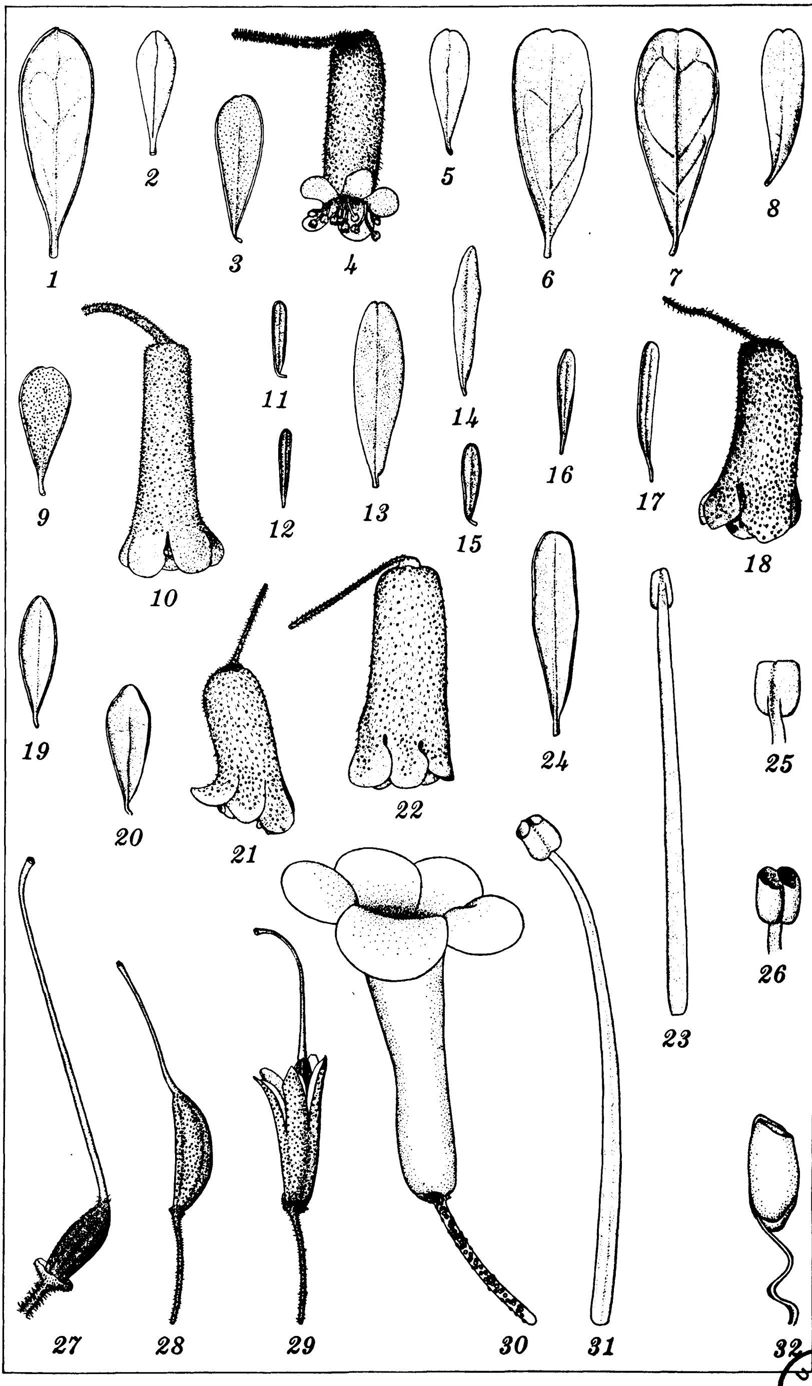
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PLATE 1.

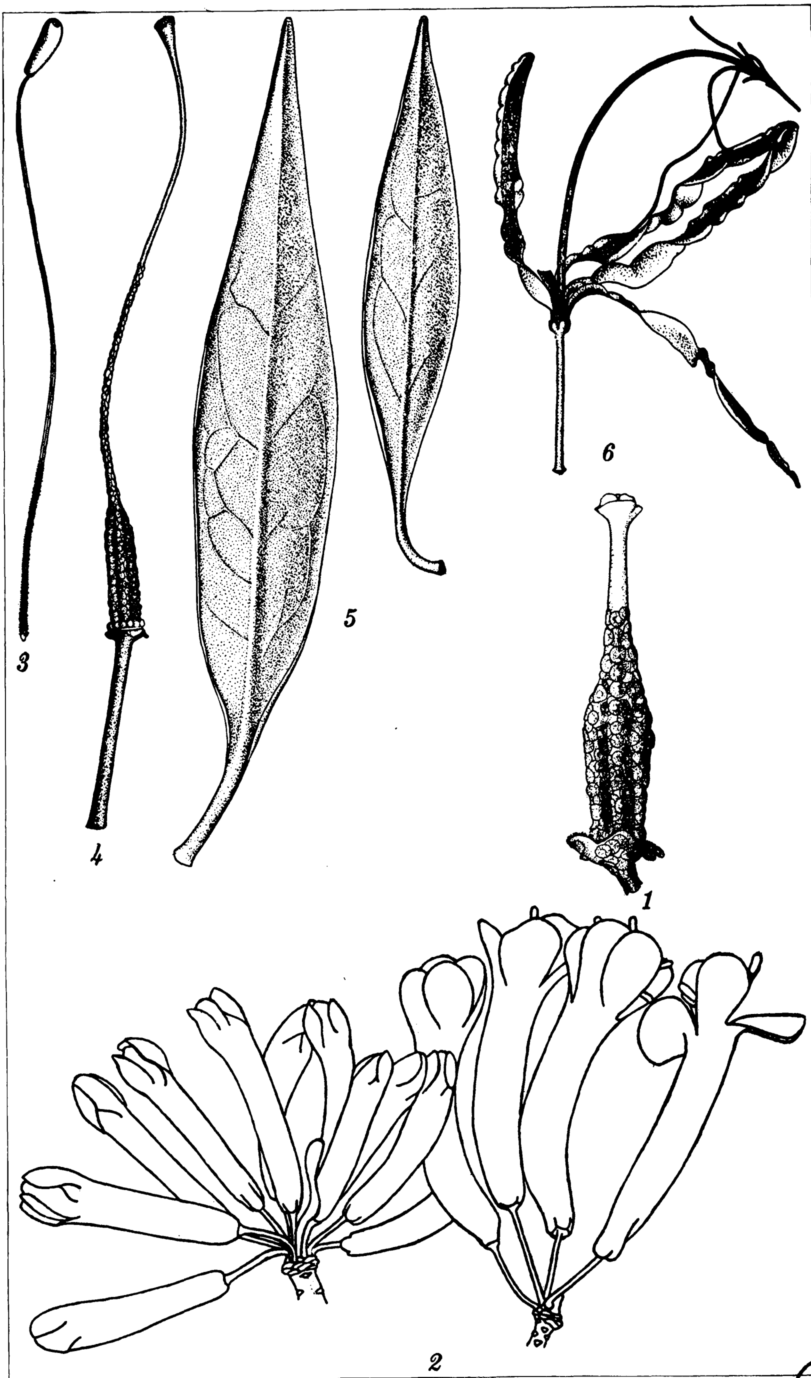


PLATE 2.

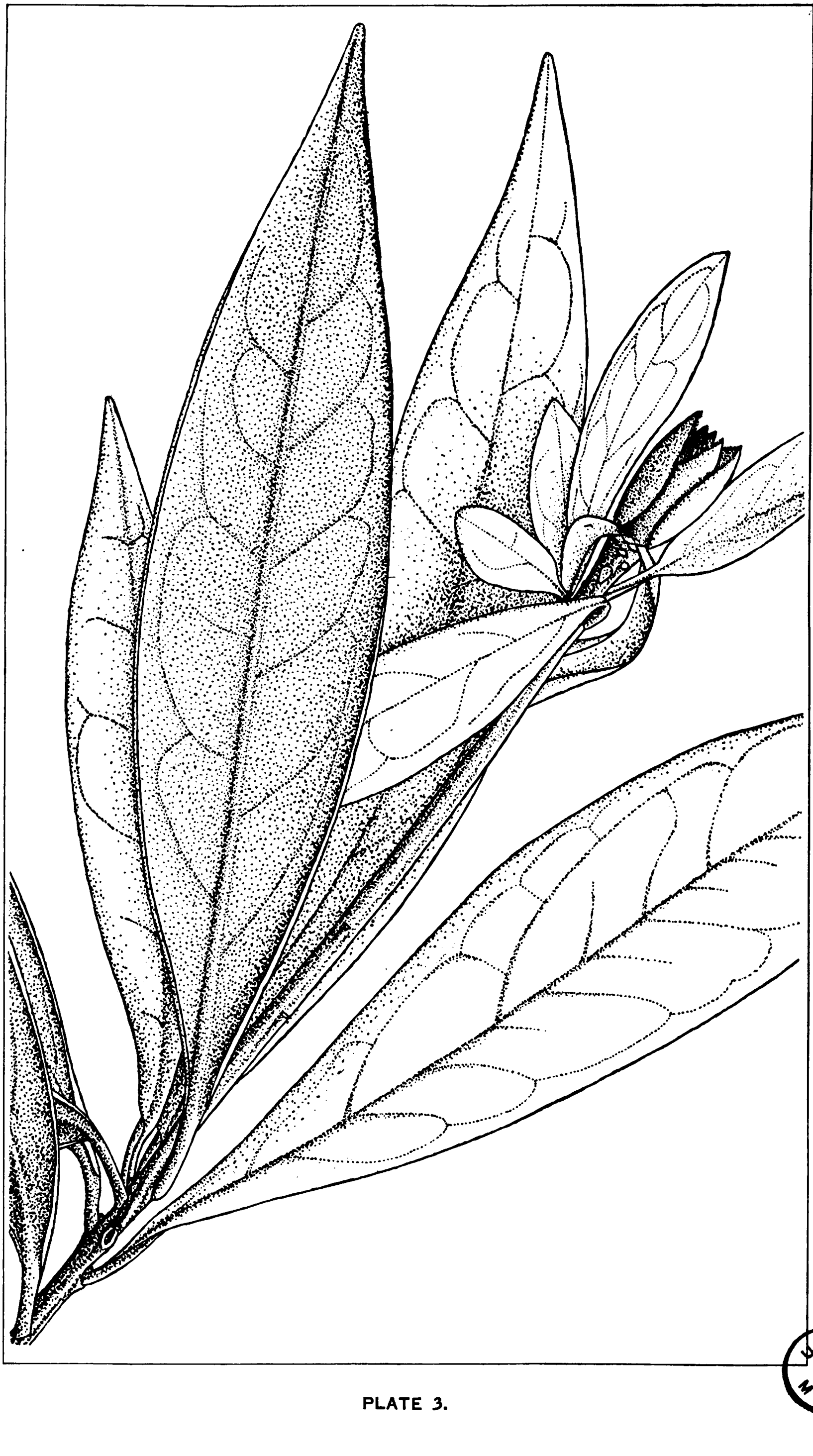


PLATE 3.

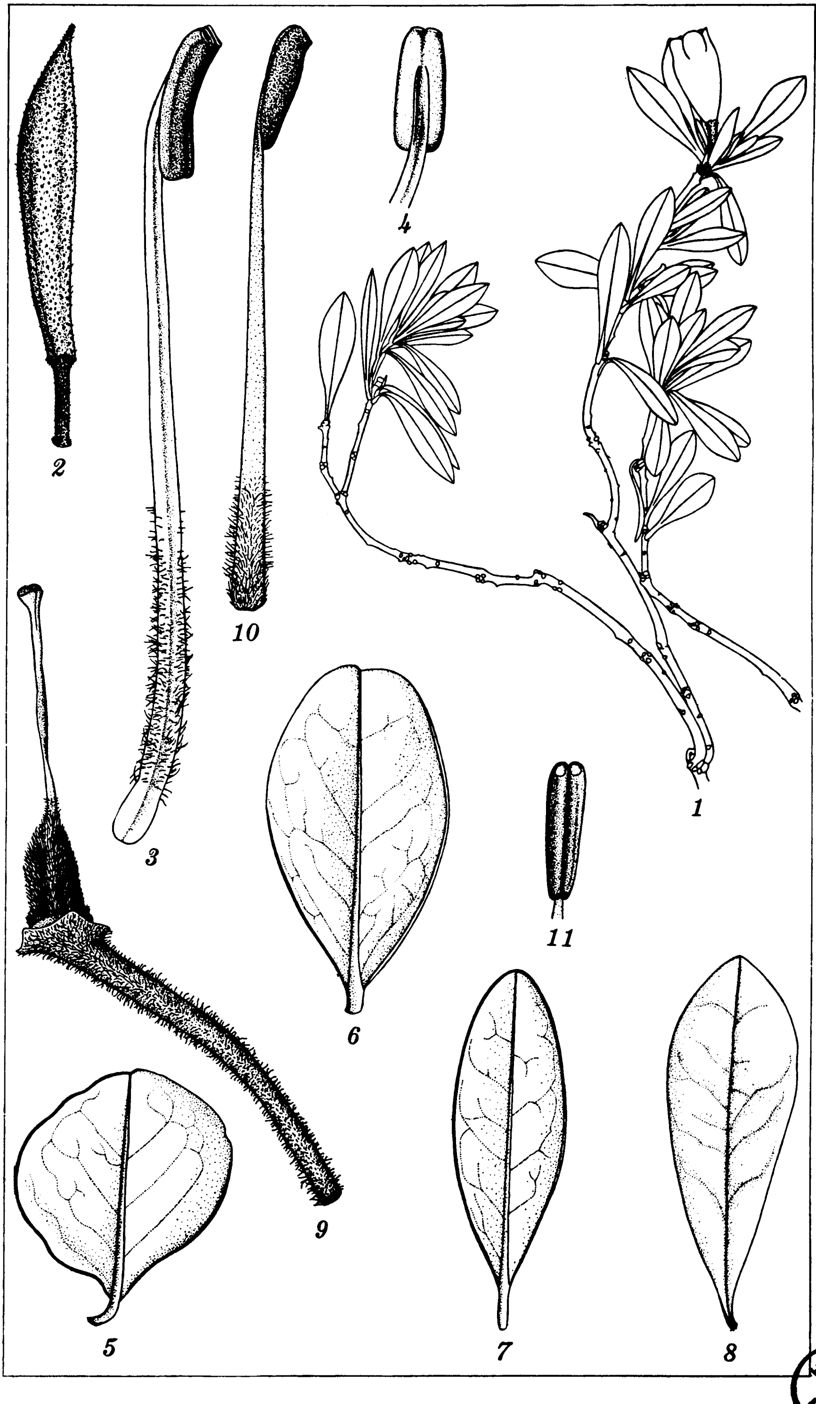
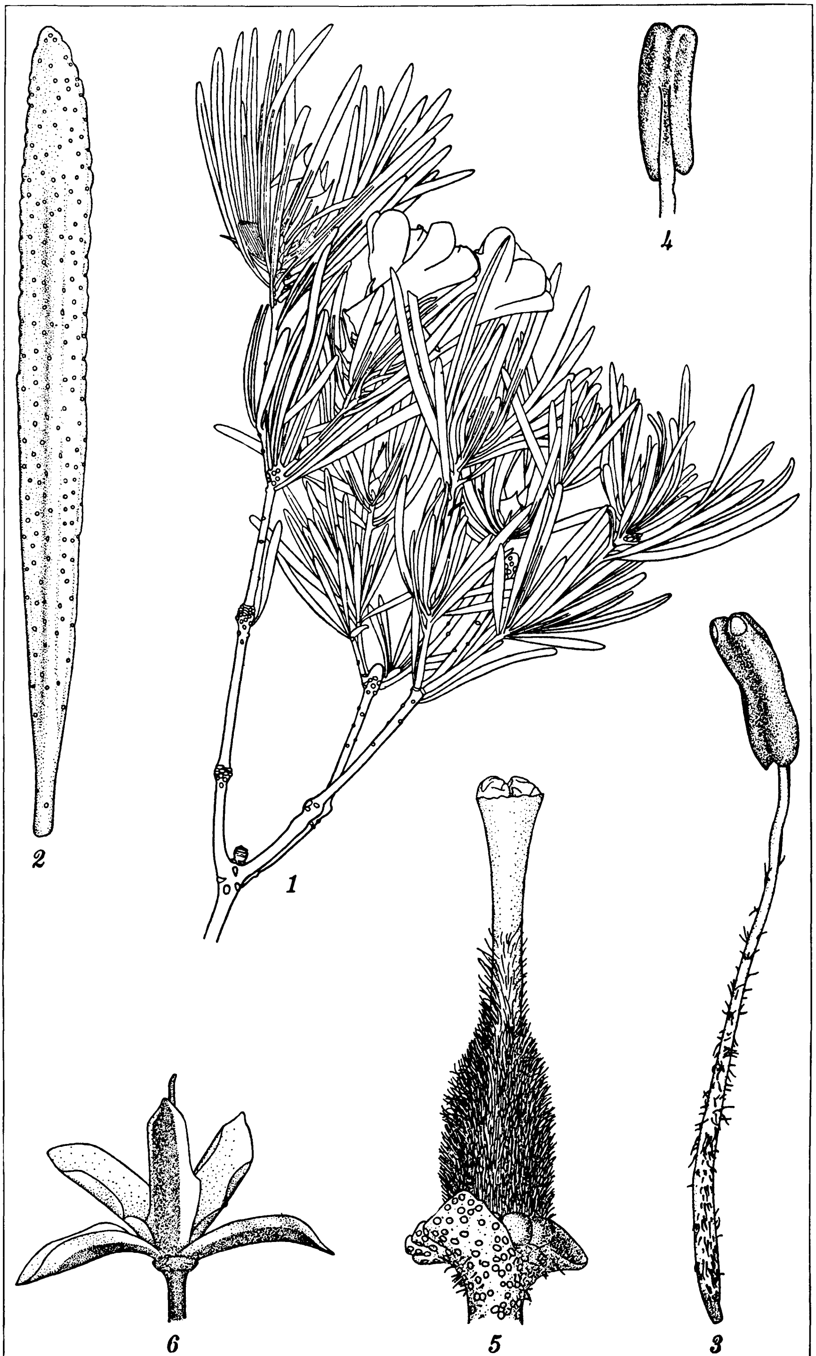


PLATE 4.

PLATE 5.



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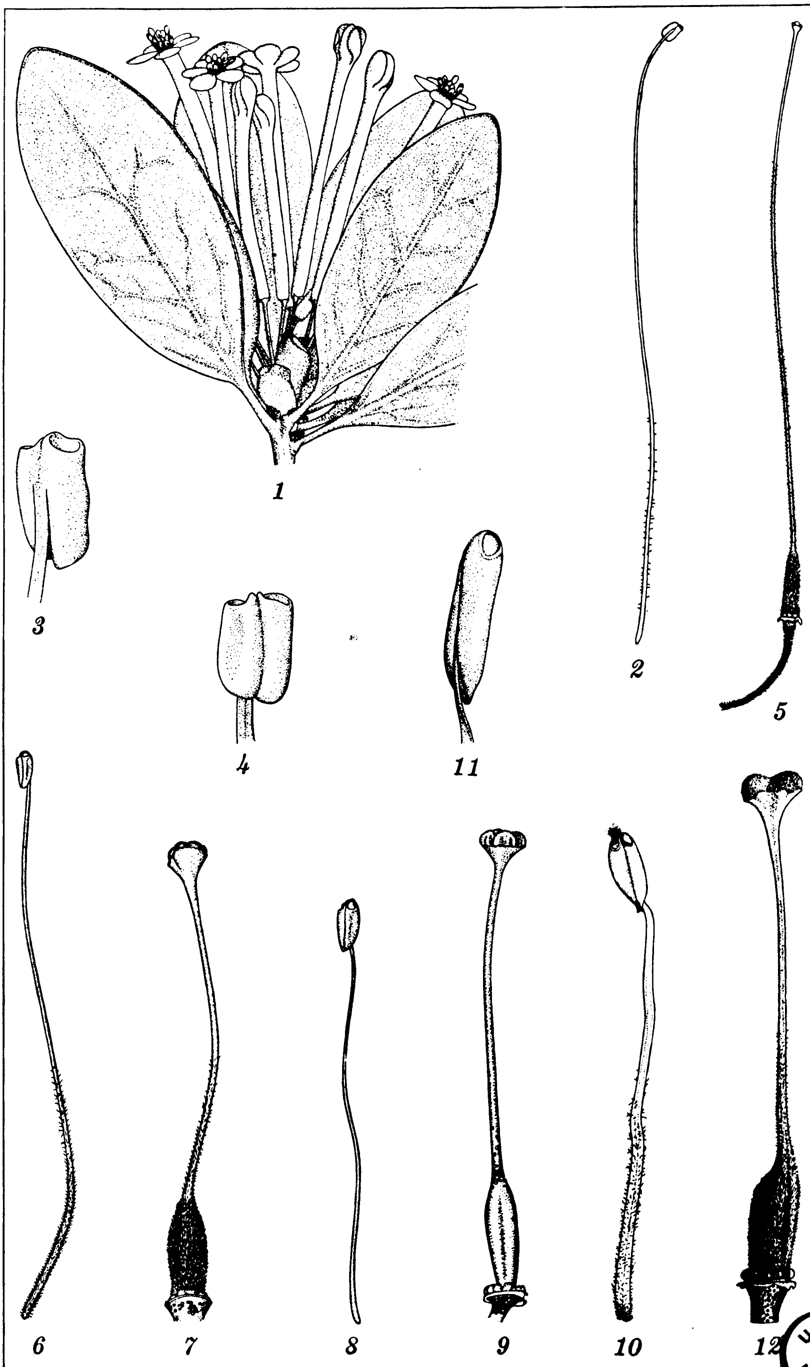

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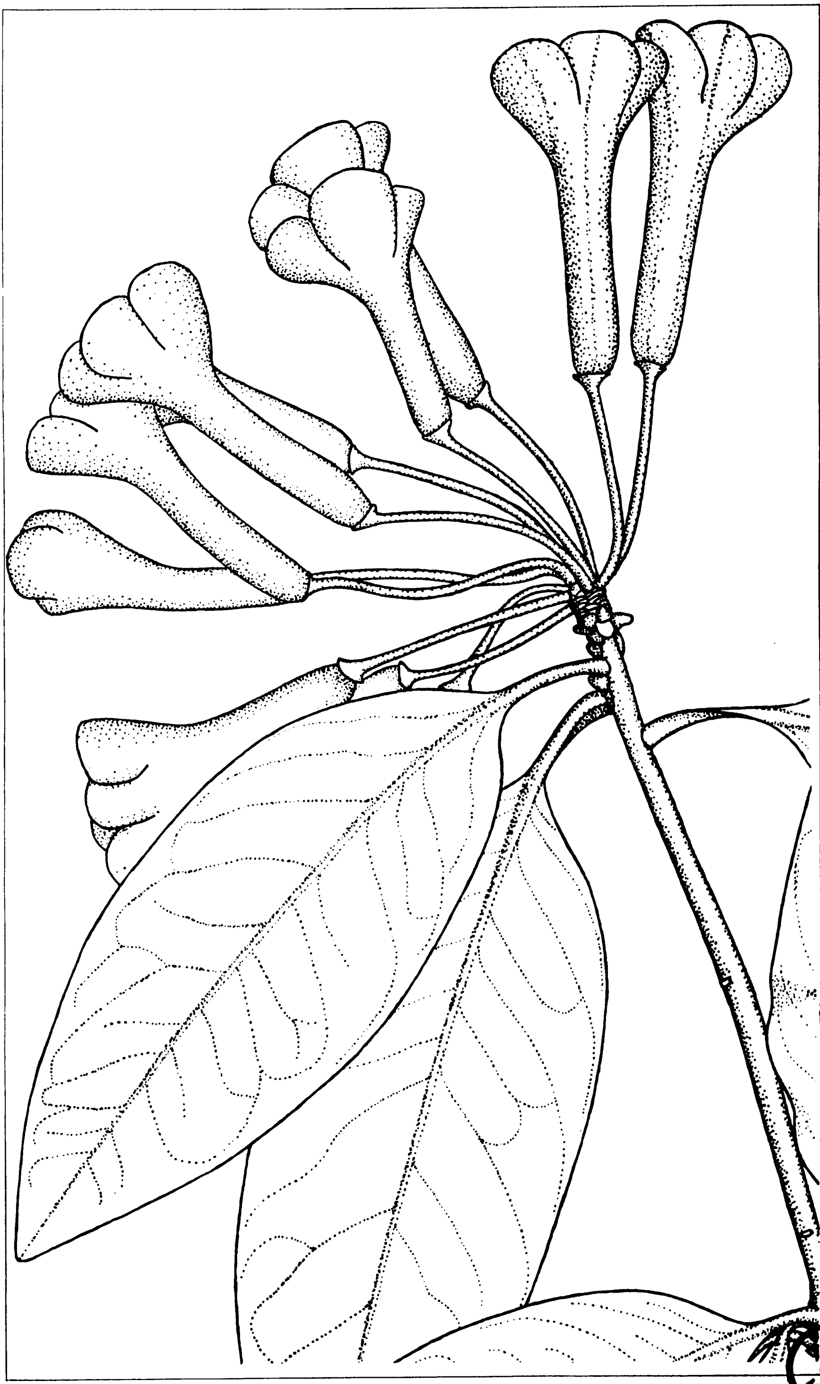

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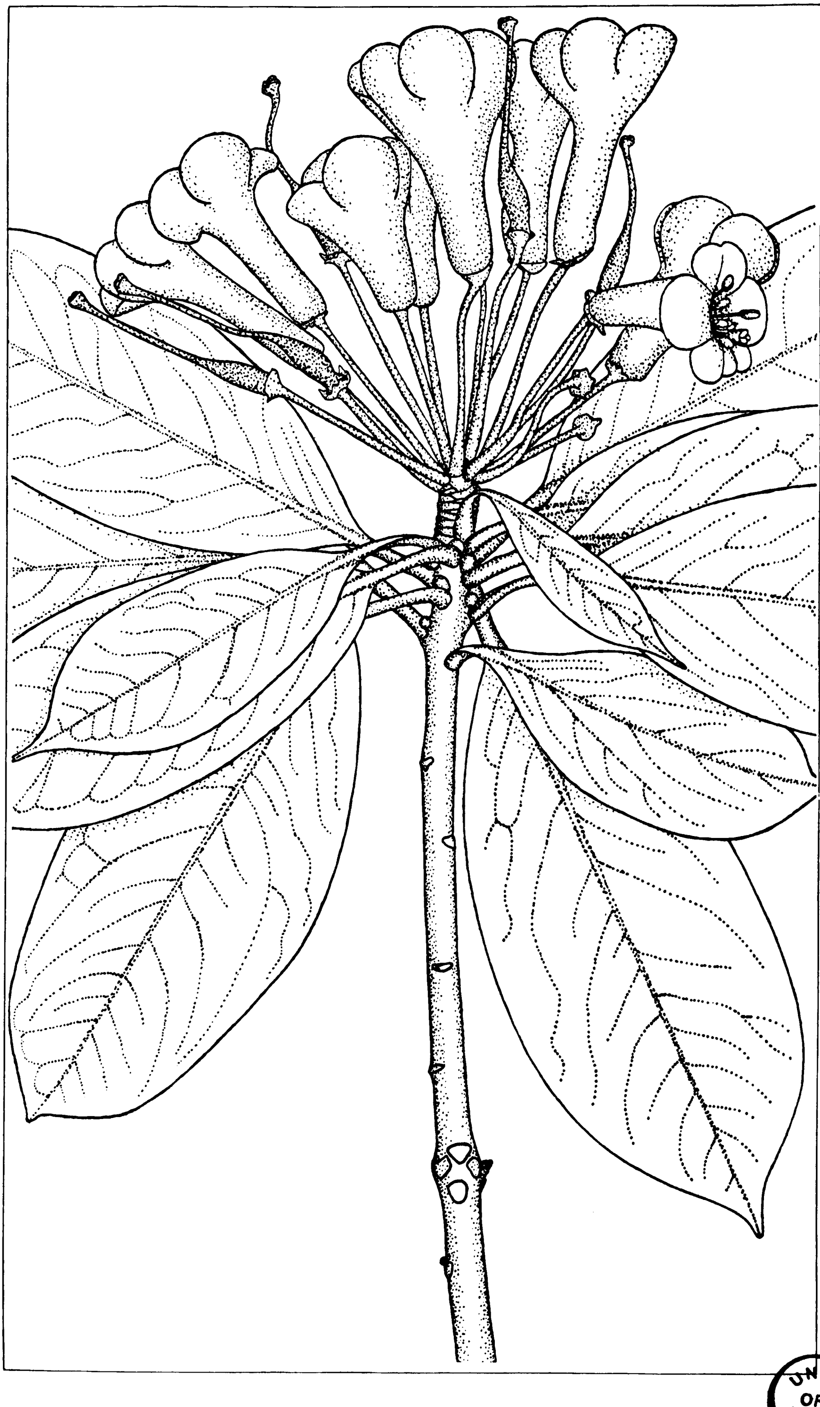

PLATE 9.

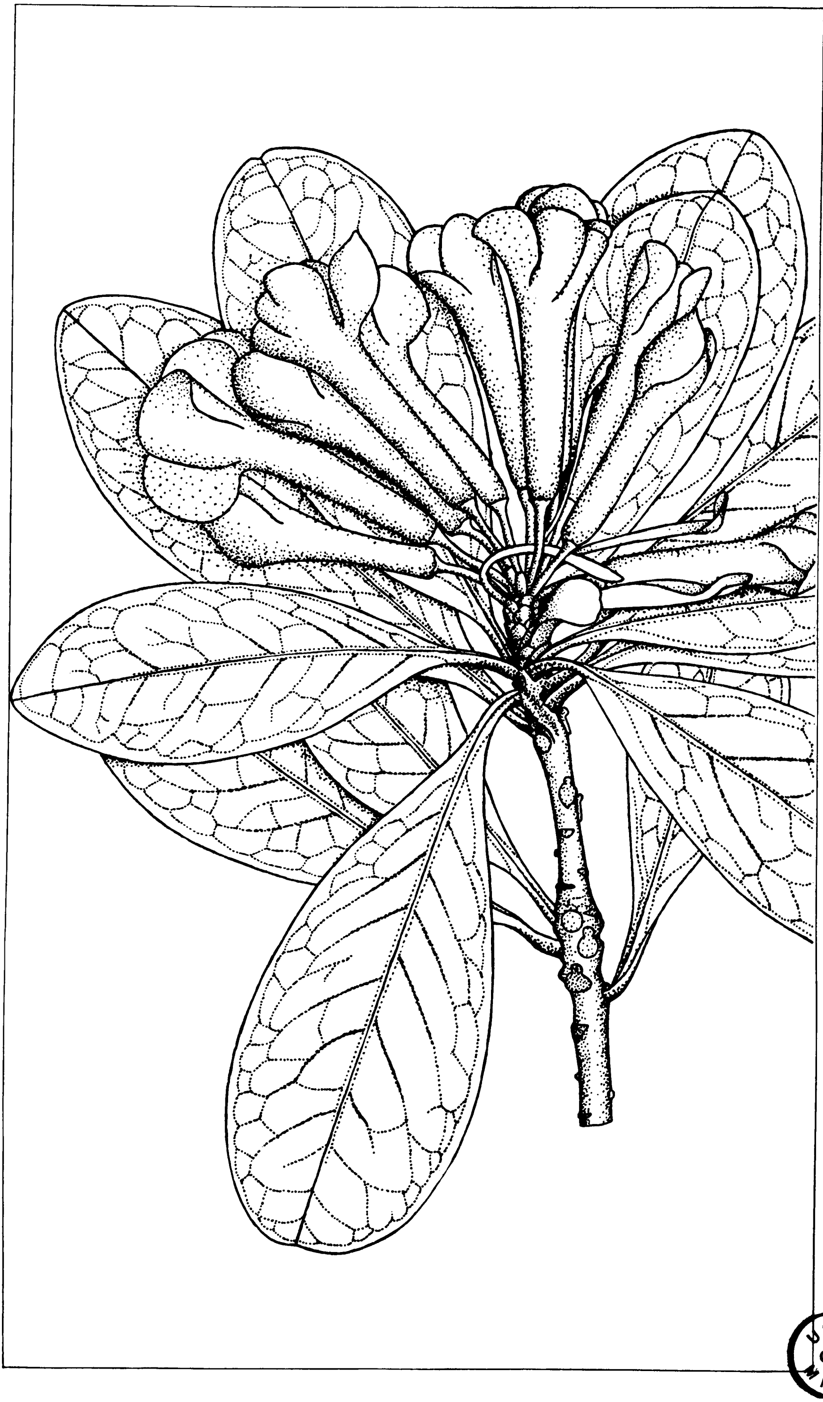

PLATE 10.

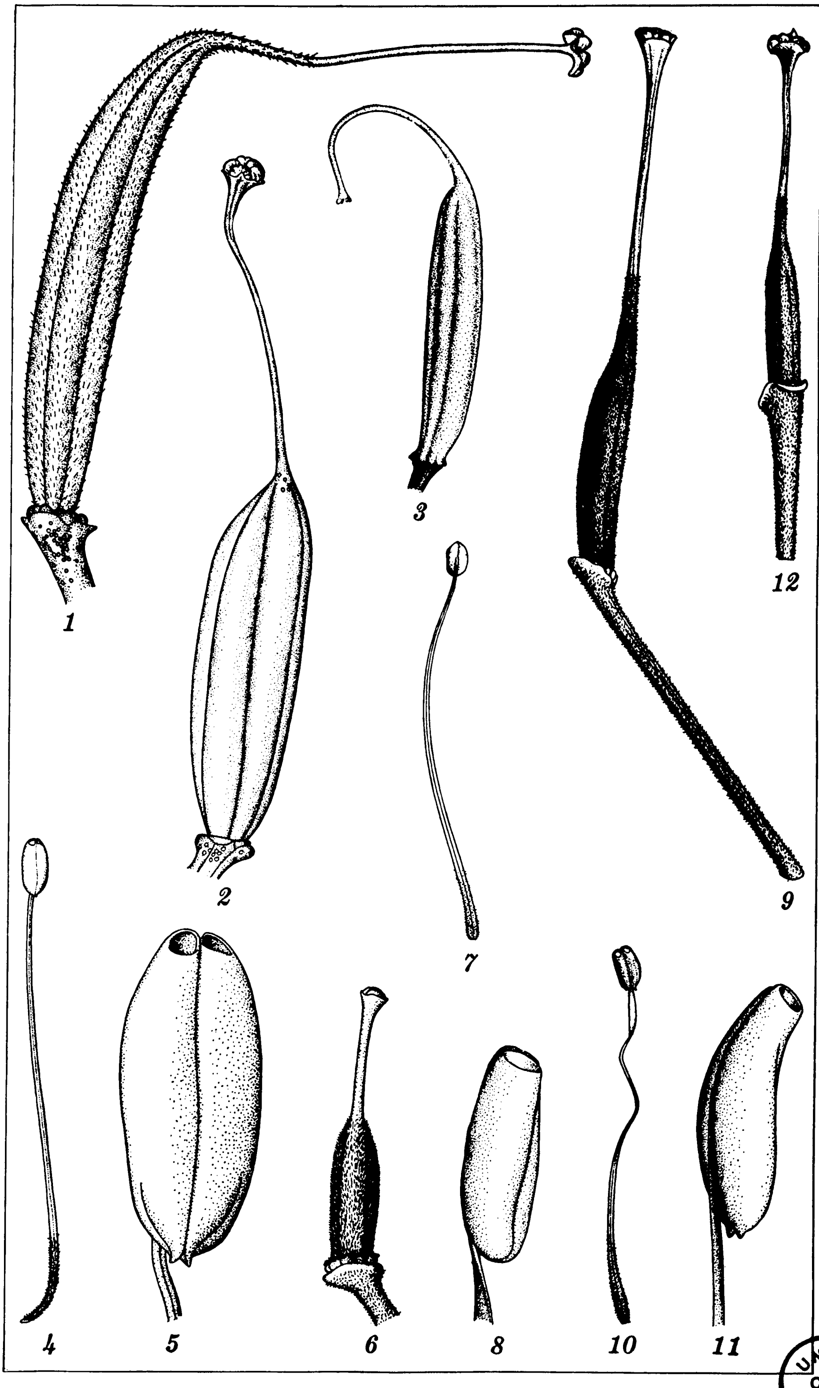

PLATE 11.

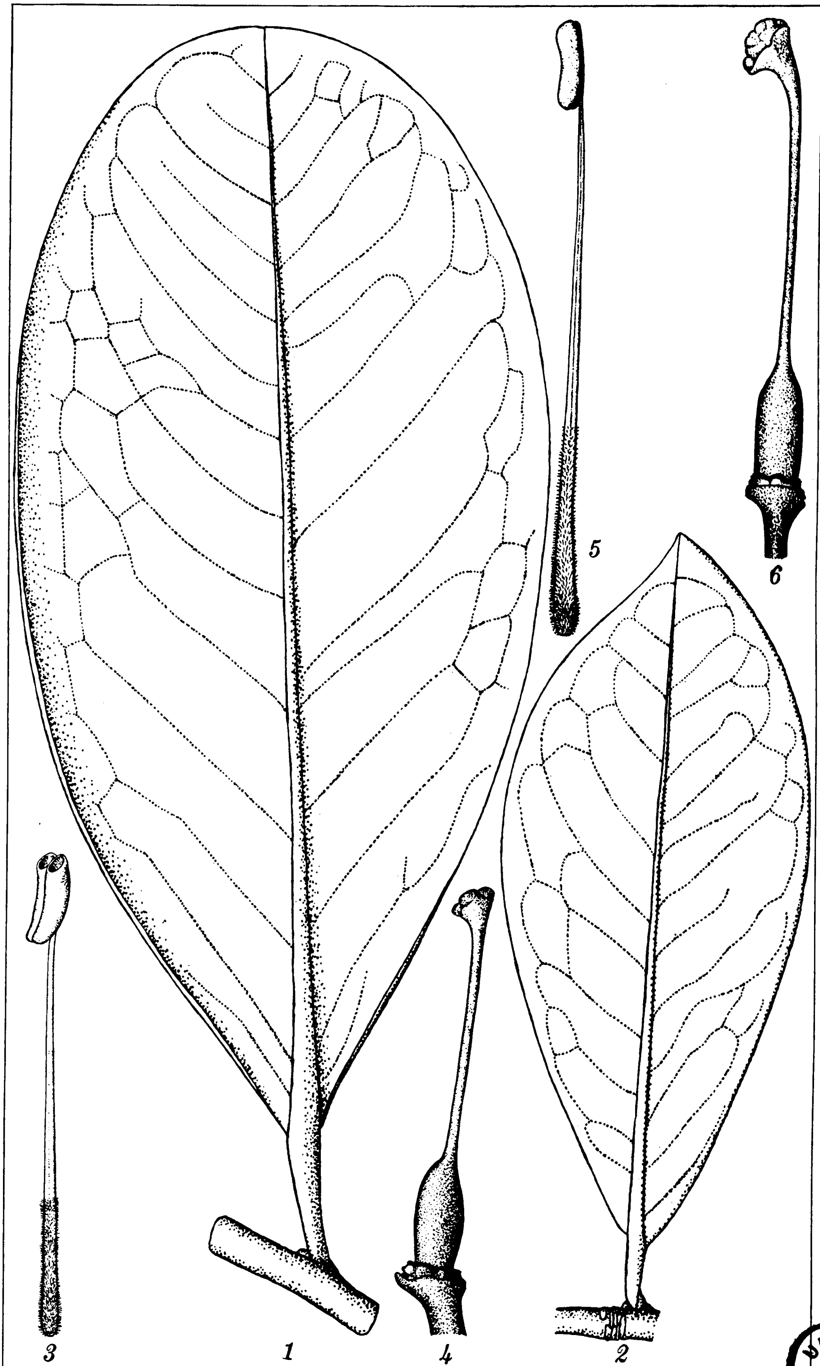

PLATE 12.

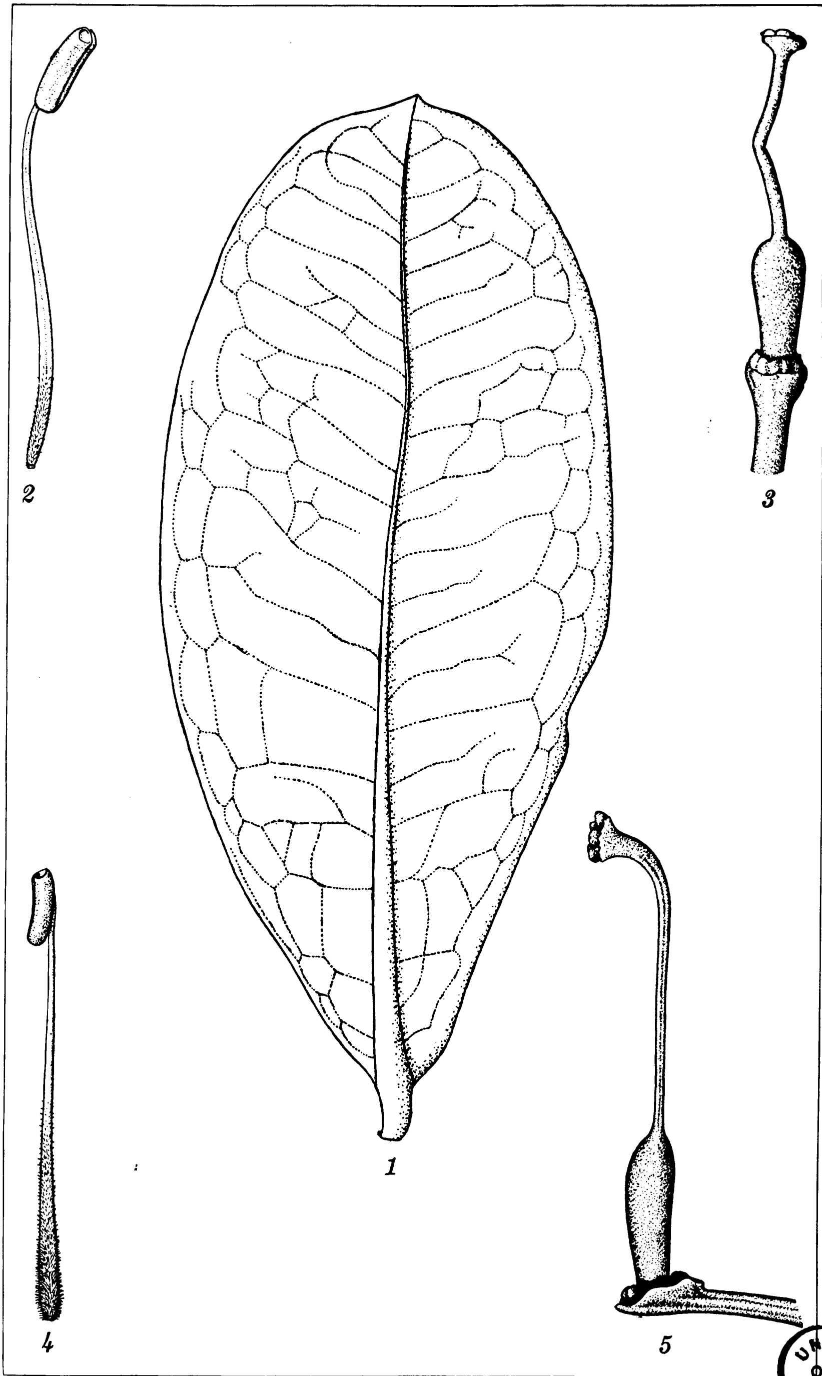

PLATE 13.

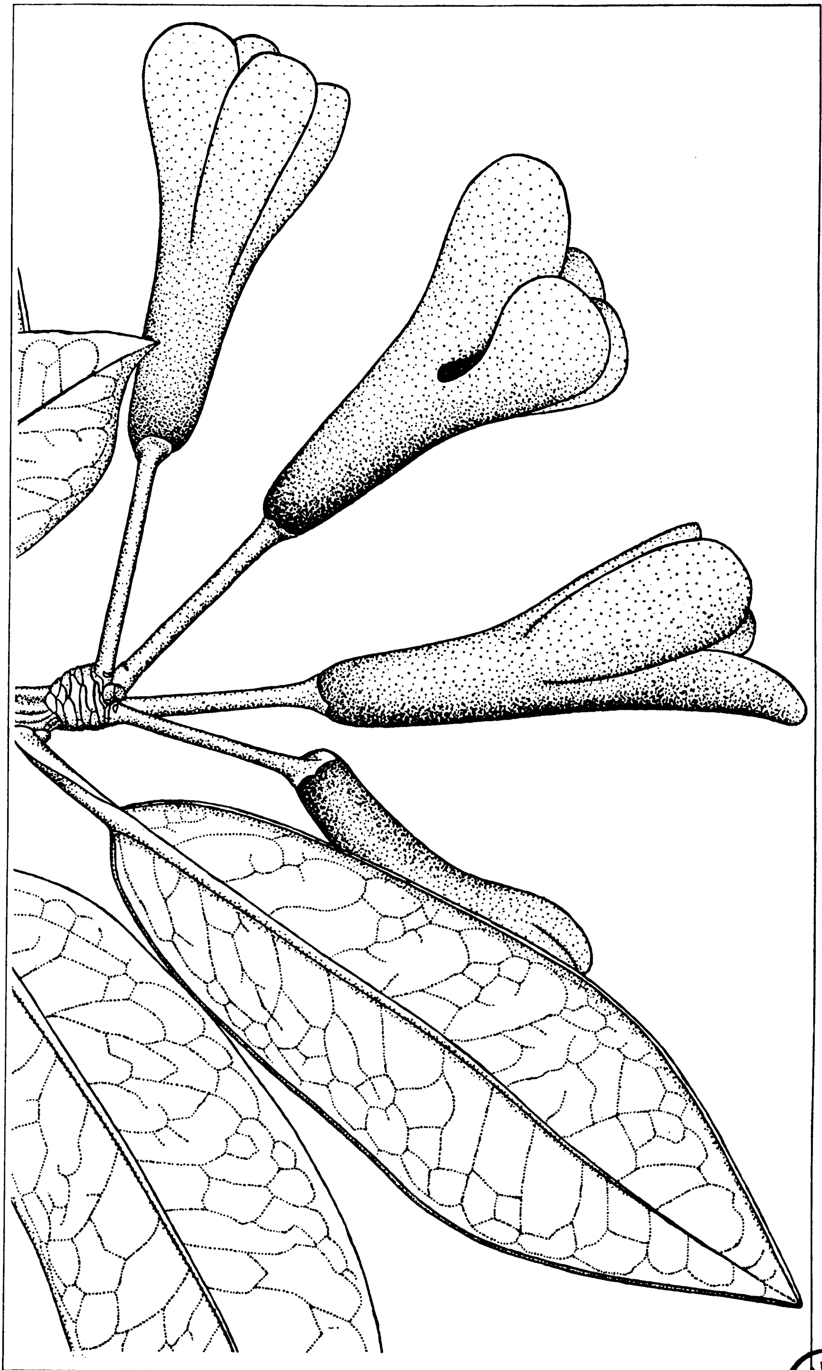

PLATE 14.

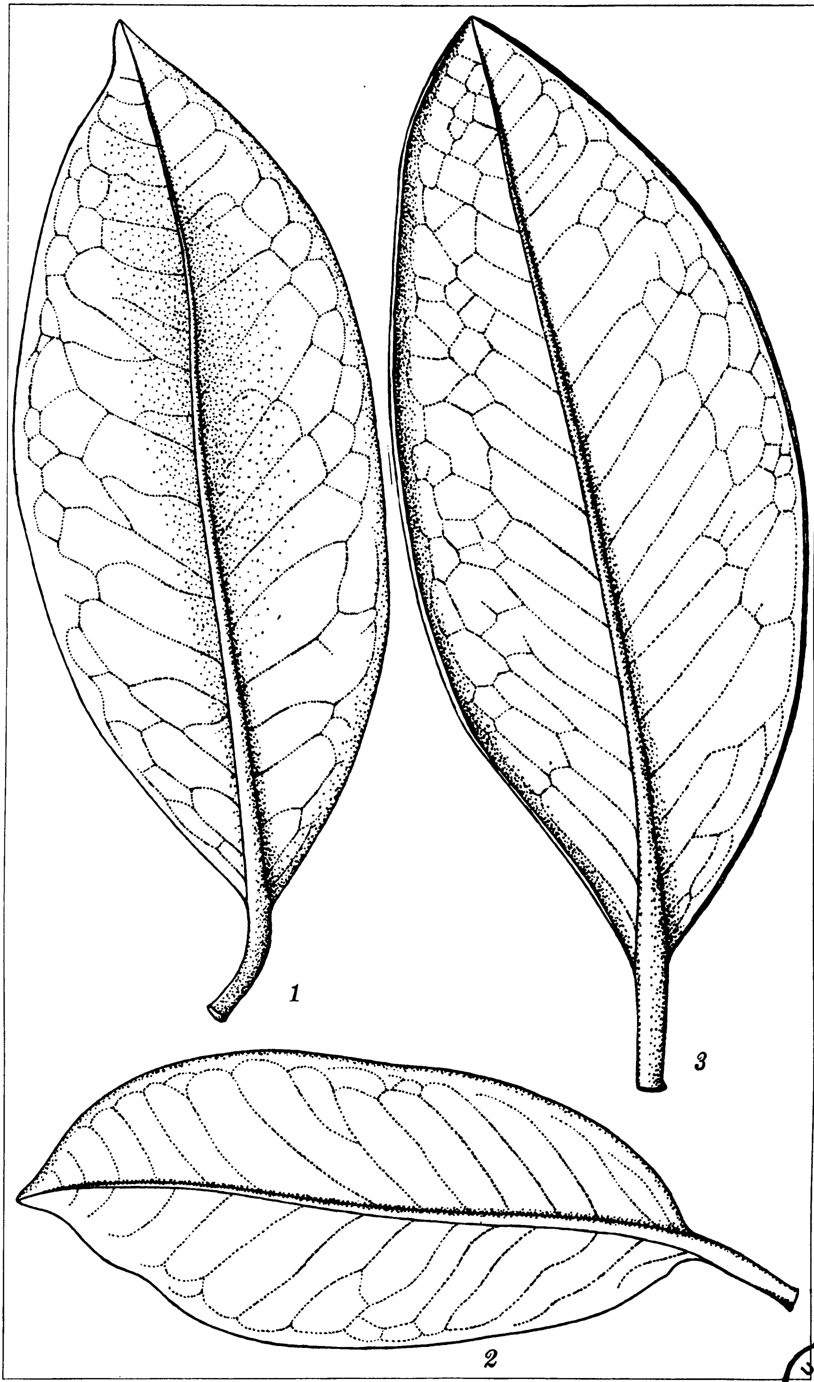

PLATE 15.

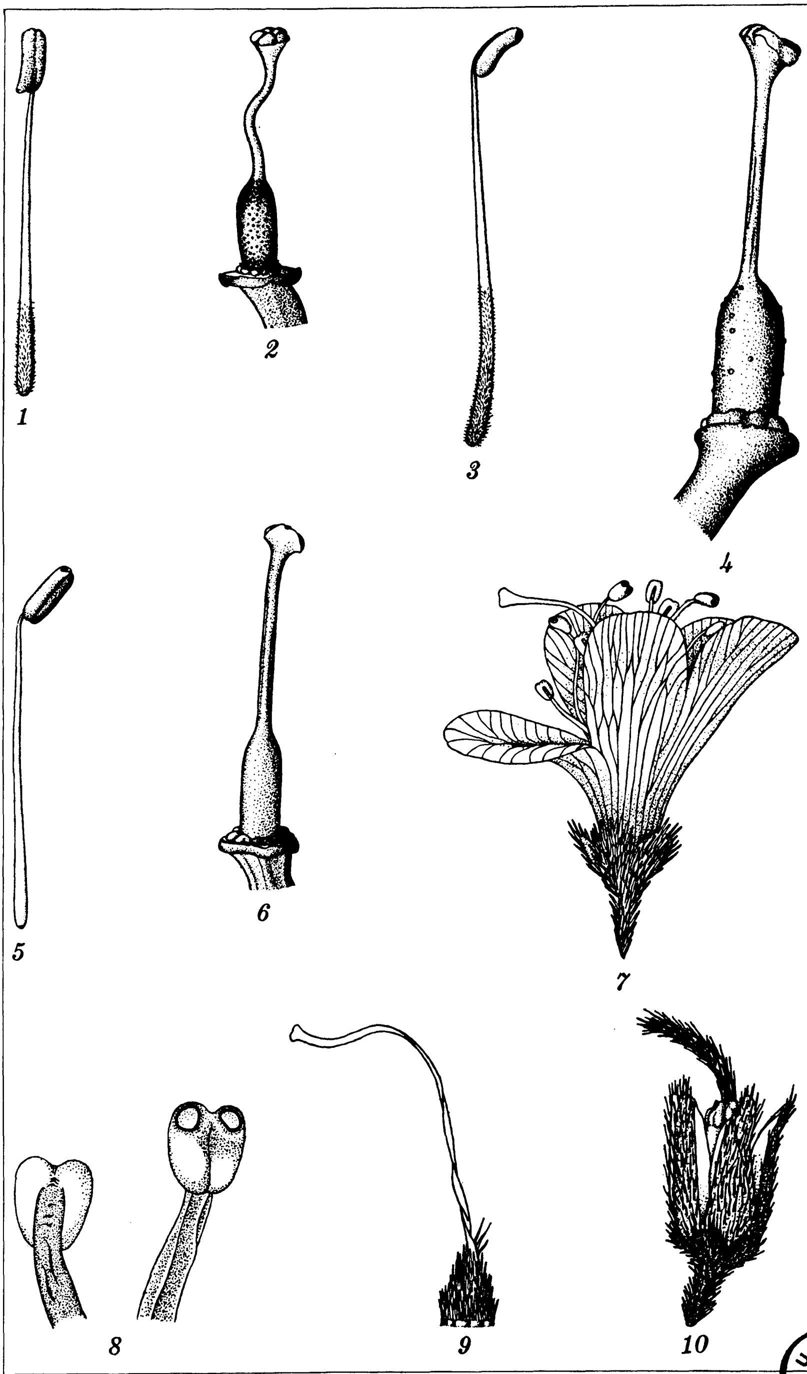

PLATE 16.

A NEW PHILIPPINE SPECIES OF CHLORIS

By E. D. MERRILL

Of the University of California, Berkeley, California

The material on which the following description is based has been in my hands for over a year, but only recently has it been possible for me to make a critical examination of it. The genus *Chloris* is very poorly developed in the Malaysian region, with only three or four species in the Philippines, of which one is certainly an introduced weed, originating in tropical America. The species described below is manifestly allied to *Chloris cynodontoides* Balansa originally described from New Caledonia, and more recently recorded from Fiji.[1]

GRAMINEÆ

Genus CHLORIS Swartz

CHLORIS CLEMENTIS sp. nov. Eueleris.

Caulibus tenuibus, compressis, glabris, prostratis, ad nodis radicantibus et ramis fasciculatis erectis gerentibus, ramis gracilibus, 15 ad 30 cm longis, ad basi foliis multis confertis gerentibus; foliis lineari-oblongis, obtusis vel acutis, 1.5 ad 4 cm longis, circiter 2.5 mm latis, margine scaberulis, utrinque glabris vel junioribus supra pilis paucis instructis; vaginis compressis, sursum ad margine ciliatis; spicis 4 ad 7, filiformibus, digitatis, 2 ad 4 cm longis, rhachibus scaberulis, basi haud villosis; spiculis 2 mm longis, sessilibus ad brevissime (0.2 mm) pedicellatis, glumis vacuis submenbranaceis, acutis vel acuminatis, 1-nervis, I 0.3 ad 0.4 mm longis, II duplo longioribus; III (florentibus) oblongo-lanceolatis, 2 mm longis, acutis, aristatis, arista filiformi, recta, scaberula 6 ad 7 mm longa; rhachilla producta (circiter 1 mm longa) glumam vacuam valde reductam vix 0.3 mm longam brevissime aristatam (arista 1 mm longa) ferente.

LUZON, Pangasinan Province, Calasiao, *Mrs. Clemens 17267*, November 30, 1926, and a second collection from the same place, February, 1927, in the thickets near the river, with *Cynodon.*

[1] Kew Bull. (1927) 43.

This species has the general habit of *Chloris tenera* (Presl) Steudel, in that the rather wide creeping stems produce roots and send up tufts of slender erect stems from the nodes, the leaves being crowded near the bases of the erect branches. In floral characters, however, it is totally different, falling in the group with *Chloris incompleta* Roth, while *C. tenera* is a representative of the section (or genus) *Eustachys*. Mr. H. N. Ridley, on the basis of a specimen sent to him direct by Mrs. Clemens, referred this grass to *Chloris cynodontoides* Balansa, of New Caledonia. While it is unquestionably allied to Balansa's species an attentive comparison of the Philippine material with the original description in my opinion indicates altogether too great discrepancies to warrant its reference to the New Caledonian and Fijian species. The bases of the spikes are not villous, and the empty glumes are much shorter, the second being distinctly shorter than the flowering glume, not exceeding it as in Balansa's species.

NOTES ON POTAMOGETONS

By A. Bennett

Of Croydon, England

Through an oversight an error beyond control was discovered in my paper on "The Potamogetons of the Philippine Islands," published in the Philippine Journal of Science 9 (1914) Botany 339–344. On page 344 I referred the following specimens: "PHILIPPINE ISLANDS, LUZON, Subprovince of Bontoc, *Vanoverbergh 209, 2684,* eight specimens on three sheets, altitude 1,290 meters, the Igorot name *ibas,*" to *Potamogeton perversus* A. Bennett; these should be *P. tepperi* A. Bennett.

Other Philippine specimens cited under *P. tepperi* A. Bennett were correctly placed.

THE MANUFACTURE OF SUGAR FROM NIPA SAP [1]

By MANUEL L. ROXAS

Of the College of Agriculture, University of the Philippines, Los Baños

EIGHT TEXT FIGURES

INTRODUCTION

The nipa palm, *Nypa fruticans* Wurmb, covers large areas of swamp land in many parts of the Tropics. In the Philippines, and elsewhere, it has served from time immemorial as a source of alcohol and crude sugar.

The palm grows in areas subject to periodical overflow of brackish tide water, usually on low river lands. It is perennial in that it continuously reproduces itself through its branching rhizomes. All the cultivation required is thinning and removal of dead leaves, to prevent overcrowding. In some places, however, the palm is planted, and reaches the bearing age in three to four years. (2) The palm varies in size according to locality. Nipa palms in Luzon are smaller than those in Panay. The palms at Kwala Semawang, British North Borneo, are very tall, and the leaves attain a length of more than 5 meters. The fruit is carried on a stalk borne on the root stock, and sticks out of the ground to a height of about 1 meter.

The sap is collected by cutting the fruit at its point of attachment to the stalk. However, a preliminary treatment is necessary. This consists in kicking or hand-shaking the fruit stalks once a week for from three to six weeks depending on the locality, the condition of the palms, or the whim of the tappers. It

[1] This report was prepared with the coöperation of Hilarion G. Henares and Getulio Guanzon and is based largely on work in the alcohol plant at Semawang, British North Borneo, where they erected a small experimental mill for the Nipa Palm Products Co., for the purpose of studying the best conditions for the manufacture of white sugar from nipa sap.

is claimed that fruit stalks which have not received this treatment do not bleed when tapped.(4)

PREVIOUS WORK ON NIPA-PALM SUGAR

Gibbs(2) was the first to suggest the possibility of manufacturing white sugar directly from nipa sap. Natives of India and the Philippines make a form of crude sugar from the nipa sap by collecting the night flow in clean dry tuquils (bamboo tubes). When such tuquils are used and the sap is collected within twelve hours, only a slight fermentation takes place. When the sap thus obtained is boiled in open pans, there results a brown mass much like the panocha made from cane, but with the flavor characteristic of nipa sugar.

Gibbs(2) demonstrated that with tuquils smeared with thick lime milk, there is practically no fermentation of the sap even after standing for twenty-four hours. The very heavily limed juice may be kept without decomposition for as long as one month.(4) Pratt, Gibbs, and others(3) found this to be true only during the first weeks of tapping while the fruit stalks are still long, but that toward the end of the tapping season lime alone does not preserve the juice. The appearance of a peroxidase in the sap collected from short stalks oxidizes the sucrose even in strongly alkaline solution. It was found that a small amount of sodium bisulphite in the milk of lime used in smearing the tuquils completely stops the action of the peroxidase. These findings are of fundamental importance in the collection of sap for white-sugar manufacture.

Several modifications of the smeared-tuquil method have been proposed. The purpose of these modifications is to reduce the amount of lime and to make its distribution in the sap more uniform.

Pratt, Gibbs, and co-workers(3) proposed the use of a funnel to carry the juice to the bottom of the tuquil containing the milk of lime, thus avoiding the tendency of the sap to form layers of gradually decreasing alkalinity. They state that even in tuquils heavily smeared with lime the top layer is often found very weakly alkaline or acidic due to fermentation because of the settling to the bottom of the heavily limed juice.

Wells and Perkins(4) proposed the use of a funnel with a bamboo head piece, a small boho stem, and a wire attachment to hold the tuquil and funnel in position.

THE COLLECTION OF SAP AT SEMAWANG

During our work at Semawang several apparently new ideas were developed. Mr. D. D. Wood, conservator of forests, State of North Borneo, conducted experiments with closed tuquils. His idea was to reduce the circulation of air necessary to the action of the peroxidase and the number of microörganisms responsible for the decomposition of the sugar in sap, and to keep out insects, which are attracted by the sweet sap and constitute the principal source of infection, besides causing some trouble in the factory, since a great number of them become drowned in the sap and must be strained out.

The idea of using moist, solid, water-slaked lime carried on a wooden float was conceived. The main difficulty in the use of the float is the tendency of the lime to drop after contact with the sap for several hours.

Another idea proposed was to use a wick soaked in lime, or lime-bisulphite mixture when the latter is needed. The wick should be hung from the mouth of the tuquil and extend to the bottom. The great objection to this method is that relatively large amounts of sap adhere to the cloth, which has to be thoroughly washed to recover sugar that would otherwise be lost.

A fourth idea, the cup method, consists in the use of a small can carried on the hole in the tuquil as shown in fig. 1. The can is provided with a baffle plate and carries either milk of lime or paste of water-slaked lime at the bottom. The purpose of the baffle plate is to force the sap to pass to within a few millimeters of the surface of the milk of lime and thus carry enough of it to make it strongly alkaline before it drops to the bottom of the tuquil.

All these methods were tried, and the results are given in the accompanying tables. Through lack of time and facilities at Semawang for making some of the devices suggested, we discontinued such experiments and resorted to the use of the original Gibbs method of collecting juices for the manufacture of sugar on a commercial scale. Mr. Wood, however, ordered for trial one hundred galvanized-iron tubes provided with cap and rubber attachment, as shown in fig. 2. The tubes did not arrive until near the close of the season, and only a few trials could be run with them. The result of these trials are given in Tables 1, 2, 3, 4, 5, and 6.

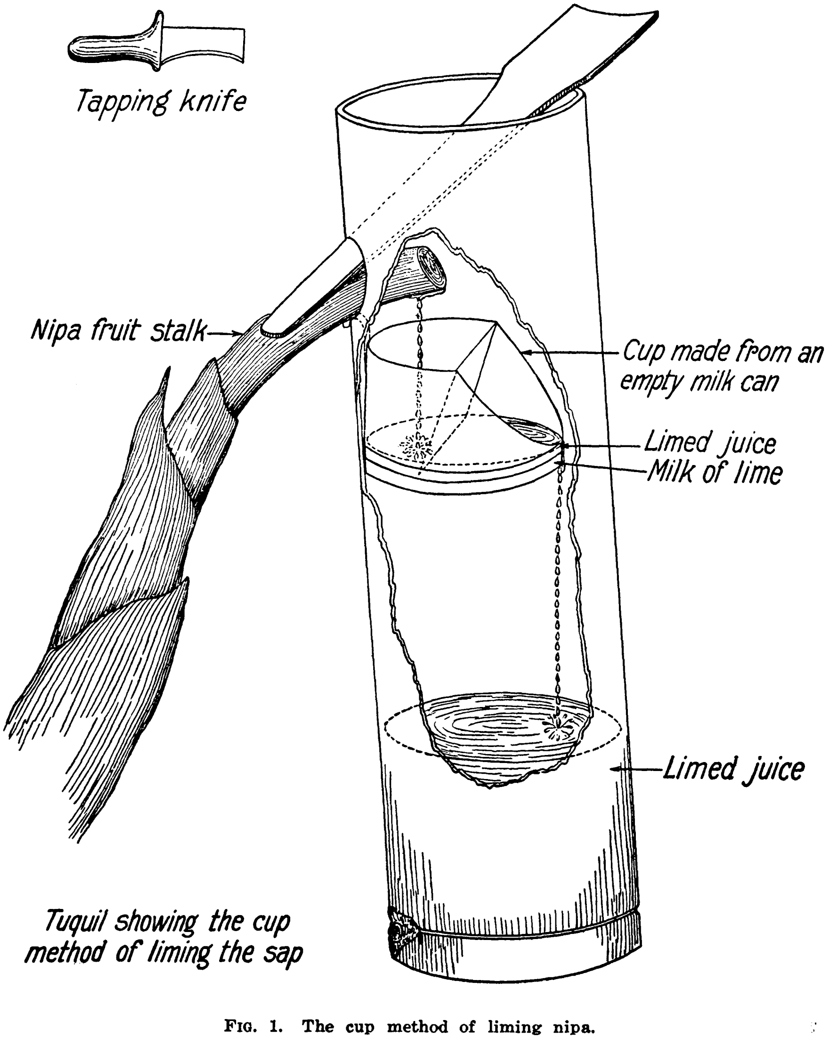

FIG. 1. The cup method of liming nipa.

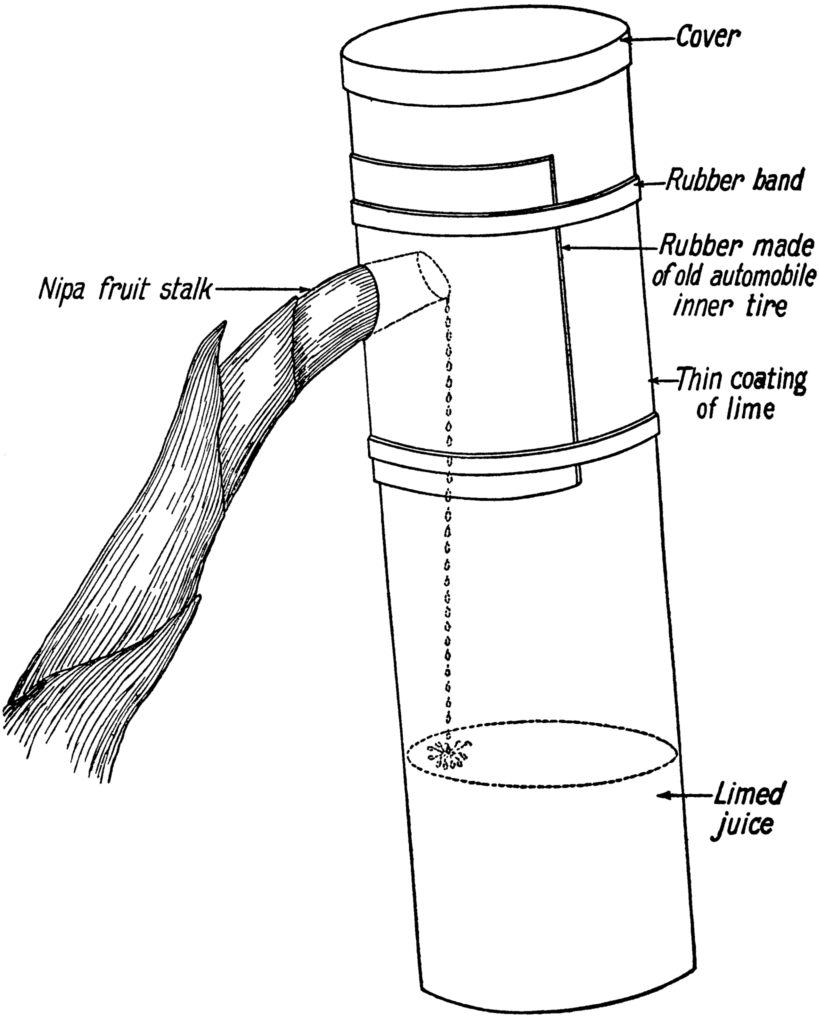

FIG. 2. The Wood tin tube for collecting nipa sap.

TABLE 1.—*Preservation of nipa sap.*

RUN 1; NIGHT FLOW; APRIL 21 TO 22, 1925.

Stand No.	Treatment.	Test-tube samples.				Tuquil samples.			
		1 per cent polarization.	2 per cent polarization.	Average per cent polarization.	Average of each treatment.	C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.
1	Float method	16.3	14.9	15.6		18.16	14.9		
2	Do.	16.2	14.8	15.5		17.62	(a)		
3	Do.	19.9	18.0	19.0	16.7	20.86		14.9	
4	Smearing method	15.6	14.6	15.1		17.76	15.1		+1.9
5	Do.	18.3	17.4	17.8		20.06	17.1		+2.5
6	Do.	17.4	15.8	16.6	16.5	18.86	16.5	16.4	+1.4
7	Funnel method	17.7	17.2	17.5			15.2		
8	Do.	16.8	15.4	16.1		18.16	16.4		
9	Do.	18.2	16.5	17.5	17.0	19.59	16.9	15.8	+3.8
	Average	17.4	16.1	16.8		18.88	16.0		

RUN 2; NIGHT FLOW; APRIL 22 TO 23, 1925.

Stand No.	Treatment.	1 per cent polarization.	2 per cent polarization.	Average per cent polarization.	Average of each treatment.	C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.
1	Float method	16.5	14.2	15.3		(b)			
2	Do.	16.8	14.2	15.5					
3	Do.	19.0	17.7	18.4	16.4				
4	Smearing method	16.8	14.5	15.5					
5	Do.	18.7	16.8	17.8					
6	Do.	17.2	16.6	16.9	16.7				
7	Funnel method	17.2	17.1	17.1					
8	Do.	16.9	15.3	16.1					
9	Do.	18.0	16.5	17.2	16.8				
	Average	17.5	15.8	16.7					

RUN 3; DAY FLOW; APRIL 23, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	Test-tube samples. 2 Per cent polarization.	Test-tube samples. 3 Per cent polarization.	Test-tube samples. Average of each treatment.	Tuquil samples. C. Brix.	Tuquil samples. Per cent polarization.	Tuquil samples. Average polarization of each treatment.	Tuquil samples. Alkalinity.
1	Float method	14.2	14.8	14.5			12.6		
2	Do	14.2	15.3	14.7		Brix			
3	Do	17.7	18.2	17.9	15.7		17.3	15.0	
4	Smearing method	14.3	14.7	14.5		not	12.7		
5	Do	16.8	16.6	16.7			15.3		
6	Do	16.5	16.5	16.5	15.9	taken	14.4	14.1	
7	Funnel method	17.1	17.2	17.2					
8	Do	15.5	16.6	15.9			14.7		
9	Do	16.5	17.6	17.0	16.7		15.9	15.8	
	Average	16.9	16.4	16.2			14.7		

RUN 4; NIGHT FLOW; APRIL 23 TO 24, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	Test-tube samples. 2 Per cent polarization.	Test-tube samples. 3 Per cent polarization.	Test-tube samples. Average of each treatment.	Tuquil samples. C. Brix.	Tuquil samples. Per cent polarization.	Tuquil samples. Average polarization of each treatment.	Tuquil samples. Alkalinity.
1	Float method	14.8	13.9	14.3					
2	Do	15.3	13.9	14.6		18.11	13.4		2.0
3	Do	18.2	14.9	17.6	15.5	20.17	10.9	12.2	
4	Smearing method	14.7	13.8	14.2		18.24	13.5		25.0
5	Do	16.6	17.6	17.1		25.37	16.7		51.5
6	Do	16.5	16.6	16.6	16.0	20.57	14.8	15.0	27.3
7	Funnel method	17.2	16.5	16.8		21.11	14.0		27.0
8	Do	16.6	14.9	15.8		17.77	16.6		2.5
9	Do	17.6	16.5	17.0	16.5	20.71	14.2	14.9	29.5
	Average	16.4	15.6	16.0		20.09	14.5		

[a] Too dark to polarize.

[b] The juice fermented before it could be analyzed.

TABLE 1.—*Preservation of nipa sap*—Continued.

RUN 5; DAY FLOW; APRIL 24, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average of each treatment.	Tuquil samples. C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.
1	Float method	13.9	15.3	14.6			13.8		13.6
2	Do	13.9	16.2	15.0		19.24	14.3		14.0
3	Do	16.9	18.2	17.6	15.7	21.31	16.6	14.9	10.5
4	Smearing method	13.8	14.3	14.0			13.2		12.5
5	Do	17.6	18.4	18.0			16.9		20.2
6	Do	16.6	16.3	16.4	16.1	20.11	14.8	15.0	27.8
7	Funnel method	16.5	17.1	16.8			14.2		13.9
8	Do	14.9	15.5	15.2			13.9		38.4
9	Do	16.5			16.0		14.2	14.1	
	Average	15.6	16.4	16.0		20.2	14.7		

RUN 6; NIGHT FLOW; APRIL 24 TO 25, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average of each treatment.	Tuquil samples. C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.
1	Float method	15.3	(c)	15.3		17.6	13.5		5.7
2	Do	16.2		16.2		17.3	10.0		(d)
3	Do	13.2		18.2	16.6	14.5	10.7	11.4	(d)
4	Smearing method	14.3		14.3		17.4	12.6		11.2
5	Do	18.4		18.4		21.2	17.1		16.0
6	Do	16.3		16.3	16.3	19.6	14.9	14.9	16.0
7	Funnel method	17.1		17.1		18.5	12.1		3.2
8	Do	15.5		15.5		17.6			(d)
9	Do				16.3	18.4	13.1	12.6	6.5
	Average	16.4		16.4		18.00	13.00		

[c] Fermented before it could be analyzed.

[d] Neutral.

TABLE 2.—*The preservation of nipa sap.*

RUN 1; NIGHT FLOW; APRIL 29 TO 30, 1925.

Stand No.	Treatment.	Test-tube samples.				Tuquil samples.				
		1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average polarization of each treatment.	C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.	Average of each treatment.
1	Float method	16.9	15.2	16.0	----------	18.2	16.0	----------	1.4	----------
2	Do.	15.9	14.7	15.3	----------	18.3	14.8	----------	4.0	----------
3	Do.	15.0	12.7	13.8	15.0	16.0	13.6	14.8	0.6	2.0
4	Smearing method	18.5	17.1	17.8	----------	20.6	16.8	----------	6.7	----------
5	Do.	15.1	15.9	14.5	----------	17.0	13.7	----------	3.5	----------
6	Do.	15.4	14.0	14.7	15.7	16.0	14.5	15.0	1.7	4.0
7	Funnel method	16.5	15.5	16.0	----------	----------	----------	----------	1.6	----------
8	Do.	13.3	11.9	12.6	----------	14.4	12.1	----------	0.9	----------
9	Do.	15.6	13.9	14.7	14.4	16.7	14.7	13.4	0.7	1.1
	Average	15.8	14.3	15.0	----------	17.2	14.5	----------	2.3	----------

RUN 2; DAY FLOW; APRIL 30, 1925.

Stand No.	Treatment.	1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average polarization of each treatment.	C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.	Average of each treatment.
1	Float method	16.2	16.0	15.6	----------	18.58	13.94	----------	11.7	----------
2	Do.	14.7	15.5	15.1	----------	19.16	13.23	----------	17.3	----------
3	Do.	12.7	14.5	13.6	14.8	16.96	10.85	12.67	15.9	15.0
4	Smearing method	17.1	17.1	17.1	----------	----------	----------	----------	----------	----------
5	Do.	13.9	14.3	14.1	----------	----------	----------	----------	----------	----------
6	Do.	14.0	14.6	14.3	15.2	18.36	13.36	13.36	13.5	13.5
7	Funnel method	15.5	16.1	15.8	----------	17.36	15.11	----------	0.3	----------
8	Do.	11.9	12.8	12.3	----------	----------	----------	----------	2.8	----------
9	Do.	13.9	14.4	14.1	14.1	----------	----------	15.11	6.0	3.0
	Average	14.3	15.0	14.6	----------	18.08	13.3	----------	9.6	----------

TABLE 2.—*The preservation of nipa sap*—Continued.

RUN 3; NIGHT FLOW, APRIL 30, TO MAY 1, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average polarization of each treatment.	Tuquil sample. C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.	Average of each treatment.
1	Float method	16.0	14.4	15.2		17.52	10.78		[a]	
2	Do	15.5	14.0	14.7		17.72	11.46		[b]	
3	Do	14.5	12.3	13.9	14.6	15.62	9.68	10.64	[b]	
4	Smearing method	17.1	16.5	16.8		18.52	12.19		2.4	
5	Do	14.3	12.1	13.7		14.92	9.26		0.6	
6	Do	14.6	13.6	14.1	14.7	17.42	11.46	10.97	[b]	
7	Funnel method	16.1	14.8	15.4		16.92	13.36		4.2	
8	Do	12.8	11.3	12.0		14.42	10.17		5.4	
9	Do	14.4	13.9	14.1	13.8	14.92	11.18	11.57	[a]	
	Average	15.0	13.7	14.3		16.44	11.06			

RUN 4; DAY FLOW; MAY 1, 1925.

Stand No.	Treatment.	Test-tube samples. 1 Per cent polarization.	2 Per cent polarization.	Average per cent polarization.	Average polarization of each treatment.	Tuquil sample. C. Brix.	Per cent polarization.	Average polarization of each treatment.	Alkalinity.	Average of each treatment.
1	Float method	14.4	15.6	15.0		17.16	10.95		3.0	
2	Do	14.0	15.4	14.7		16.62	11.26		1.4	
3	Do	12.3	14.5	13.4	14.4	16.22	10.84	11.02	11.1	4.8
4	Smearing method	16.5	17.2	16.8					18.7	
5	Do	12.1	14.0	13.0					18.8	
6	Do	13.6	14.7	14.1	14.6	17.06	11.72	11.72	13.7	17.1
7	Funnel method	14.8	16.8	15.8		17.84	14.35		4.4	
8	Do	11.3	12.3	11.8		14.94	9.87		9.6	
9	Do	13.9	11.5	12.7	13.4	15.26	11.40	11.87	2.0	5.3
	Average	13.7	14.7	14.4		16.44	11.48		9.1	

[a] Slightly acidic.

[b] Acidic.

TABLE 3.—*Experiments with closed tuquils conducted by Mr. D. D. Wood.*

Date.	Brix.	Polarization.	Purity.	Alkalinity.	Time.
STAND A.					
					Hrs.
May 6	17.19	12.90	75.0	Slightly acidic	14
May 7	16.99	10.01	59.0	do	24
May 8					
May 9	16.01	8.54	53.4	Acidic	24
May 10	18.20	8.56	47.1	Slightly acidic	24
May 12	20.02	14.72	73.6	10.6	24
May 13	17.81	9.49	53.5	Acidic	24
Average	17.70	10.70	60.5		
STAND B.					
May 6	18.66	12.14	65.2	Slightly acidic	14
May 7	16.89	12.89	74.3	do	24
May 8					
May 9	18.30	12.48	68.3	3.5	24
May 10	17.7	11.02	62.3	Neutral	24
May 12	19.32	15.28	79.8	6.4	24
May 13	18.71	10.92	58.4	Acidic	24
Average	18.26	12.46	68.2		
STAND C.					
May 6	18.99	14.01	73.7	2.7	14
May 7	13.19	8.24	62.6	Slightly acidic	24
May 8	13.2	3.68	27.9	Acidic	24
May 9	12.99	2.23	17.2	Neutral	24
May 10	14.0	7.12	50.8	Slightly alkaline	24
May 12	14.82	11.72	79.1	2.1	24
May 13	14.21	5.69	40.1	Acidic	24
Average	14.49	7.53	52.0		
STAND D.					
May 6					
May 7	13.79	10.28	79.0	Slightly acidic	24
May 8	13.70	5.35	39.1	Acidic	24
May 9	13.49	2.48	18.4	do	24
May 10	13.70	4.16	30.4	Slightly acidic	24
May 12	15.62	12.58	80.6	1.8	24
May 13	15.21	4.40	42.2	Acidic	24
Average	14.25	7.00	49.1		
STAND E.					
May 6					
May 7	15.09	12.46	82.5	Neutral	24
May 8	15.00	9.80	65.4	Acidic	24
May 9	14.70	4.39	29.9	do	24
May 10	14.90	7.39	49.7	Neutral	24
May 12					
May 13					
Average	14.92	8.51	57.0		

TABLE 4.—*Results with the cup method of distributing lime.*

Stand No.	May 10, 1925.				May 11, 1925.				May 12, 1925.			
	C. Brix.	Polarization.	Purity.	Alkalinity.	C. Brix.	Polarization.	Purity.	Alkalinity.	C. Brix.	Polarization.	Purity.	Alkalinity.
1	20.81	13.85	66.6	3.7	19.89	11.10	55.8	[b]	[a]	[a]	[a]	----
2	[a]	[a]	[a]	[b]	20.99	16.49	78.6	4.0	18.96	13.26	80.5	1.9
3	20.61	16.96	82.2	4.3	21.69	17.51	80.7	3.3	19.46	15.28	78.6	[c]
4	20.78	14.71	70.8	8.9	19.19	15.36	80.0	[c]	21.16	16.69	78.8	5.0
5	20.51	16.23	79.3	3.6	18.89	11.87	62.8	[c]	[a]	[a]	[a]	
6	20.28	12.19	60.01	2.6	----	----	----	----	----	----	----	----
7	19.88	16.51	83.2	2.4	----	----	----	----	----	----	----	----
8	22.11	16.99	76.8	8.6	----	----	----	----	----	----	----	----
Average[d]	20.71	15.35	74.12	4.9	20.13	14.47	71.9	1.5	19.86	15.74	79.3	2.3

[a] Fermented. [b] Acidic. [c] Neutral. [d] General average: C. Brix, 20.23; per cent polarization, 15.19; purity, 75.1; alkalinity, 2.9 cubic centimeters.

TABLE 5.—*Comparative results obtained by using tin and bamboo tuquils.*

Date.	Coolie 2.								Coolie 5.							
	Tin.				Bamboo.				Tin.				Bamboo.			
	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.
May 24	19.58	12.72	65.0	2.7	21.08	13.70	65.3	4.3	18.18	11.34	62.4	3.9	18.96	12.36	65.2	4.8
May 25	20.90	12.50	59.8	12.3					17.70	10.83	61.0	7.4				
May 26	20.6			13.4	19.50			6.6	18.00			11.5				
May 27	20.4			13.6					18.6			12.5				
May 28	21.8	11.97	54.9	20.2					20.0	10.28	51.4	20.9				
May 29	20.7	12.19	58.9	13.4					18.6	11.07	59.5	5.9				
May 30	20.51	13.49	65.8	13.4					17.31	11.21	64.8	7.2				
General average																

Date.	Coolie 8.								Average.							
	Tin.				Bamboo.				Tin.				Bamboo.			
	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.	C. Brix.	Polarization.	Purity.	Alcalinity.
May 24	19.78	13.51	68.3	3.8	19.68	11.12	56.5	6.1	19.18	12.52	65.3	3.5	19.91	12.39	62.2	5.1
May 25	19.8	15.0	75.7	8.7	19.80	12.8	64.6	13.8	19.47	12.78	65.6	9.5	19.80	12.8	64.6	13.8
May 26	20.31	12.09	59.5	12.7	19.21	10.95	57.3	9.2	19.64	12.09	61.6	12.5	19.36	10.95	56.6	7.9
May 27	20.61	11.08	57.3	15.4	20.54	11.80	57.6	15.4	19.87	11.80	59.4	13.8	20.54	11.80	57.6	15.4
May 28	21.5	12.09	59.2	16.4	20.60	11.71	56.8	11.9	21.10	11.45	54.3	19.2	20.60	11.71	56.8	11.9
May 29	19.1	10.90	57.1	3.8					19.47	11.39	58.5	7.7				
May 30	21.01	12.26	58.4	17.2	21.11	11.29	53.5	13.2	19.61	18.32	62.8	12.6	21.11	11.29	53.5	13.2
General average									19.76	12.05	61.0	11.3	20.22	11.82	58.5	11.2

TABLE 6.—*Composition of test-tube samples from various fields, May 30, 1925.*

Stand No.	Field 1.			Field 2.			Field 3.			Field 4.			Field 5.			Field 8.		
	Refractometer solids.	Polarization.	Purity.	Refractometer solids.	Polarization.	Purity.	Refractometer solids.	Polarization.	Purity.	Refractometer solids.	Polarization.	Purity.	Refractometer solids.	Polarization.	Purity.	Refractometer solids.	Polarization.	Purity.
1	21.0	17.83	84.9	19.3	16.20	83.9	18.2	14.70	80.8	20.3	17.24	84.9	19.9	17.37	87.3	19.6	16.49	84.6
2	19.4	13.33	79.0	21.0	18.40	87.6	20.5	16.91	82.5	19.9	17.09	85.9	18.0	15.38	85.4	22.1	17.34	78.5
3	19.3	14.42	73.9	18.4	15.05	81.8	21.3	16.69	78.4	22.0	19.82	90.1	19.0	16.96	89.3	22.6	18.77	83.1
4	19.3	15.38	79.7	19.3	16.35	84.7	20.4	18.64	91.4	20.3	17.20	84.7	18.9	16.09	85.1	21.4	17.51	81.8
5	21.3	17.53	82.4	22.0	19.62	89.2	20.6	17.48	84.9	20.0	17.18	85.9	19.0	16.72	88.0	19.9	17.28	86.8
6	19.4	14.51	74.8	19.9	17.04	85.6	20.6	17.87	86.7	20.2	17.28	85.5	20.1	17.81	88.6	21.0	17.25	82.1
7	20.7	17.58	84.9	19.3	16.83	86.3	22.0	18.96	86.2	21.5	17.80	82.8	19.0	15.99	84.2	20.2	16.89	83.6
8	21.3	18.09	84.9	21.1	16.22	80.2	20.6	17.06	82.8	20.0	17.42	87.1	18.5	15.98	86.4	21.5	18.13	84.3
9	18.7	15.25	81.6	21.0	18.31	87.2	20.4	17.30	84.8	19.3	15.33	79.4	19.9	17.04	85.6	23.0	19.36	84.2
10	19.5	16.06	82.4	21.2	16.60	87.7	19.9	16.61	87.5	19.7	17.08	86.7	19.3	16.88	87.5	19.3	16.54	85.7
Average [a]	20.61	16.20	80.85	20.3	17.33	85.4	20.45	17.22	84.2	20.32	17.34	85.3	19.16	16.62	86.7	21.05	17.55	83.4

[a] General average: Refractometer, 20.3; per cent polarization, 17.04; purity, 83.94.

RESULTS OF COLLECTION EXPERIMENTS

Several reasons led us to adopt the original Gibbs smeared-tuquil method for the commercial collection of sap. Of all the methods tried, it is the simplest and surest. We discovered too that strong alkalinity in the juice is unobjectionable, and is even desirable in sugar manufacture, since heavy liming is very effective in removing gums and resinous matter found in the nipa sap collected by the ordinary process.

During the first few weeks of collection, we followed the recommendation of Pratt and others(3) to pass sulphur dioxide through lime instead of using sodium bisulphite as they did in their experiments, believing with them that such treatment was sufficient to stop the activity of the peroxidase, which we supposed was present in the sap, since at the time we conducted our experiments, the fruit stalks had already been tapped for several months and were nearing the end of the season. As may be seen in Tables 8 and 9, giving the composition of juices from day to day, we were having trouble in collecting good juices at first and by no method we used could we obtain juice good enough for white-sugar manufacture. The sucrose content was much less than that found in saps collected directly in clean test tubes containing a few drops of toluene. All the stands being tapped in one field were examined for peroxidase, and we found positive proof of its presence in every case, as is shown by the effect on tincture of guaiacum; in many cases the addition of hydrogen peroxide was unnecessary to bring out the blue color.

In view of the fact that we were obtaining poor juices with the use of lime milk treated with sulphur dioxide, we decided to use lime milk mixed with sodium bisulphite prepared from sodium carbonate and sulphur dioxide and later from sodium hydroxide and sulphur dioxide. The lime milk was mixed as follows:

A solution of 4 per cent sodium carbonate was made. Sulphur dioxide was passed through it until acidic, and the solution thus made was used in preparing a thick lime milk of 50° Brix, which was used in smearing the tuquils in a central station. The smearing was done by putting a small amount of lime milk in the tuquil and pouring it out, rotating the tuquil at the same time, so that its sides were thoroughly soaked in lime. The

tuquil was then allowed to drain as completely as possible. The following instructions were issued for the guidance of the coolies:

May 6, 1925.

COLLECTION OF SAP USING SEVEN MALAYS AND THE SMEARING METHOD

1. Each Malay to have two tuquils per stump.
2. The tuquils to be smeared with lime-bisulphite mixture every twenty-four hours as follows:
   (*a*) All tuquils to be brought in to the smearing station where they will be cleaned, smeared, and drained, and made ready for use.
   (*b*) On first day at 2 p. m. tuquil set No. 1, smeared and ready for use, will be taken to the grove and hung on the stumps replacing tuquils Nos. 2, which will then be gathered and brought to the smearing station. The small amount of day flow to be collected and brought in to the factory at the same time.
   (*c*) On the following morning the night flow is collected. Tuquils Nos. 1 are rinsed with a little water and used again for the day-flow, floats with lime being used this time.
   (*d*) In the afternoon tuquil set No. 2, which must be ready for use will be taken to the grove to replace tuquils Nos. 1, as in (*b*), and thus the cycle of operations is repeated.
3. Mornings and afternoons the stumps must be washed with a little water, and then tapped.
4. Each coolie will take to the field the following:
   A. In the morning—
      1. Floats.
      2. Two half canfuls of water, one to be used for rinsing the stumps in the afternoon.
      3. One or more empty cans for the sap according to the amount that may be collected.
      4. Tapping knife.
   B. In the afternoon—
      1. The smeared tuquils.
      2. The empty cans.
      3. The tapping knife.
5. For the next three days one responsible person will accompany each coolie to see that he has understood instructions and to teach him how to recognize badly fermented sap with the help of litmus paper and from the appearance.
6. In collecting from each tuquil, sap that shows frothing must be placed in a different can from sap showing no frothing. Saps that are acid must be thrown away.

After adopting the method of smearing the tuquils in a central station and using sodium bisulphite, we had no further trouble in collecting good juices.

TABLE 7.—*Showing relative strength of alkali needed in preservation.*

Date.	Grams of calcium oxide (CaO) per 400 cubic centimeters of juice.											
	0.4 g. C. Brix = 20.08.		0.8 g. C. Brix = 20.18.		1.2 g. C. Brix = 20.48.		1.6 g. C. Brix = 20.78.		2.0 g. C. Brix = 20.74.		2.4 g. C. Brix = 21.17.	
	Polarization read.	Alkalinity.	Polarization read.	Alkalinity.	Polarization read.	Alkalinity.	Polarization read.	Alkalinity.	Polarization read.	Alkalinity.	Polarization read.	Alkalinity.
1925		*cc. n/5.*		*cc. n/5.*		*cc. n/5.*		*cc. n/5.*		*cc. n/5.*		*cc. n/5.*
April 28	36.7	1.0	37.0	1.7	37.7	3.1	36.5	4.2	36.5	5.9	36.5	7.3
April 29	36.7	0.95	36.9	1.7	36.5	3.05	36.5	4.25	36.5	5.8	36.6	7.4
April 30	36.5	0.75	36.9	1.65	36.6	3.0	36.6	4.25	36.4	5.5	36.5	7.2
May 1	33.6	([a])	36.8	1.5	36.6	2.8	36.5	3.8	36.4	5.2	36.6	6.8
May 2	28.7	([a])	36.9	1.4	36.8	2.7	36.6	3.8	36.6	4.7	36.5	6.4
May 3	([b])	([b])	36.7	1.3	36.8	2.6	36.7	3.7	36.5	4.7	36.5	6.3
May 5	([b])	([b])	25.1	([a])	36.4	1.5	36.6	3.5	36.6	4.5	36.4	6.2

[a] Acidic.

[b] Cannot be polarized.

TABLE 8.—*Composition of the raw juice, day by day, during the first part of the season.*

[General average: C. Brix, 17.00; per cent polarization, 8.83; alkalinity, 10.0]

Coolie No.	April 30, 1925.			May 1, 1925.			May 2, 1925.			May 3, 1925.			May 4, 1925.		
	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity n / 5.	C. Brix.	Per cent polarization.	Alkalinity n / 5.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.
1	18.6	11.5		17.4	8.8	9.6	15.96	7.02	7.4	15.2	6.11	8.7	14.91	6.4	5.0
2	14.6	7.0		14.9	11.6	14.5	13.76	4.61	12.6	12.1	2.49	12.9	11.21	3.9	9.4
3	19.0	10.3		18.8	7.5	19.1	15.96	6.18	7.1	13.4	4.06	9.6	14.21	5.4	3.8
4	19.1	13.9		17.3	8.3	7.3	17.06	8.06	15.1	14.5	5.87	4.4	13.41	6.6	16.1
5							18.26	8.21	15.4	19.4	10.45	16.3	17.31	8.0	9.8
6	15.67	7.04		17.4	11.9	8.8	18.76	9.06	17.4	18.3	8.45	15.5	16.50	8.3	6.7
7	16.3	10.6		15.1	6.5	17.2	13.66	5.11	12.1	12.5	4.53	9.0	13.91	6.6	8.0
8	18.1	10.1		16.9	8.1	7.4	19.96	9.89	24.9	17.6	7.66	7.4	17.01	8.1	8.3
9	16.2	9.1		18.3	8.9	16.3	17.86	9.00	16.3	17.3	8.44	11.2	15.61	7.4	2.1
10	17.1	10.8		18.0	11.7	11.2	15.16	8.08	(a)	18.2	9.00	13.7	17.81	7.8	16.4
11							17.76	10.37	10.1	18.7	9.08	19.7	17.11	8.8	6.4
12	20.1	15.7		18.8	11.0	5.1	21.06	11.43	23.0	19.2	10.76	15.6	20.11	12.5	10.9
13				16.1	8.9	2.9	19.06	10.66	21.9	20.3	12.09	18.5	18.21	9.9	6.2
14							20.26	12.76	14.0	19.4	10.55	11.3	18.71	10.6	3.1
15	17.4	11.5		17.1	10.2	4.4	18.56	10.10	15.1	16.9	6.31	17.2	17.91	9.0	11.6
16	20.6	12.5		19.3	9.8	17.7	20.26	10.49	28.5	20.4	11.56	27.2	19.01	11.4	17.8

Coolie No.	May 5, 1925.			May 6, 1925.			May 7, 1925.			Average.		
	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.
1	15.4	8.3	0.6	14.7	5.23	(a)	17.64	7.63	16.5	16.23	7.62	6.8
2	12.8	6.6	0.5	10.0	2.86	3.8				12.77	5.55	8.9
3	13.6	4.2	(a)	11.01	2.0	(a)				15.14	5.66	6.6
4	15.7	6.9	16.1	16.01	7.75	4.9				16.15	8.20	10.6
5	17.1	7.3	20.7	15.41	7.37	7.8				17.50	8.27	14.0
6	19.5	10.7	18.9	17.71	8.0	3.7				17.70	9.06	11.8
7	13.0	7.5	2.8	15.0	10.5	1.6	12.7	5.52	1.9	14.03	7.11	7.5
8	14.7	6.5	1.4	15.71	6.44	3.2				17.14	8.11	8.8
9	15.5	7.1	3.0	18.11	13.29	(a)				16.98	8.89	8.1
10	17.9	8.3	20.8	17.51	9.07	15.4				17.38	9.25	12.9
11	17.7	8.8	15.1	17.81	9.15	8.6				17.82	9.12	11.9
12	17.2	8.9	2.9	19.41	12.67	6.8				19.41	0.85	10.7
13	18.7	10.3	8.0	17.41	9.02	4.5				18.29	10.15	10.3
14	19.1	11.3	6.9	18.2	14.35	0.25				19.13	11.91	7.1
15	15.4	8.7	1.3	16.01	7.85	(a)				17.04	9.09	8.3
16	16.4	8.1	3.4	19.1	13.81	10.0	19.5	13.4	5.5	19.32	11.38	15.7

TABLE 9.—*Composition of the raw juice, day by day, during the second part of the season.*

Date.	Coolie 1.			Coolie 2.			Coolie 3.			Coolie 4.		
	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.
1925												
May 8	17.2	9.77	(c)	19.9	16.5	2.6	19.2	15.4	2.1	19.5	15.92	2.4
May 9	17.6	12.04	1.5	20.4	15.09	8.4	19.9	16.06	6.3	20.0	14.63	5.7
May 10	16.0	8.63	2.1	10.4	13.99	(a)	18.5	13.84	(b)	19.4	15.87	3.2
May 11	18.29	14.14	1.3	19.39	15.04	0.9	18.39	13.11	do.	19.29	13.88	(a)
May 12	17.69	13.21	1.2	19.89	15.90	4.7	18.49	14.42	0.2	19.09	15.80	1.2
May 13	17.7	12.68	1.2	20.0	16.17	3.1	18.7	14.65	0.4	18.5	12.62	1.1
May 14	18.11	10.7	10.1	18.81	13.86	10.0	18.01	15.08	2.95	17.71	13.54	5.6
May 15	18.5	10.83	7.9	20.6	12.76	10.0	19.3	11.66	6.0	20.2	13.56	5.6
May 16	16.82	10.5	0.4	19.83	14.14	4.0	18.52	15.54	(a)	19.42	15.67	2.0
May 17	16.52	8.42	1.0	20.02	11.73	4.1	19.62	12.0	5.5	20.12	13.47	4.6
May 18	18.47	10.40	4.7	19.64	13.16	4.6	19.84	11.82	7.7	20.64	13.29	2.8
May 19	19.7	11.17	9.1	20.1	13.47	5.5	20.0	11.97	8.3	21.0	13.80	7.9
May 20	19.9	11.97	8.2	19.4	10.16	9.3	19.9	12.21	8.0	21.0	13.18	7.3
May 21	19.4	11.12	8.8	21.2	11.15	15.3	20.24	11.63	8.7	21.32	12.81	12.1
May 22	18.7	9.71	5.0	20.7	12.86	11.3	20.5	11.66	10.3	------	------	------
May 23	------	------	------	------	------	------	------	------	------	------	------	------
May 24	18.48	10.83	1.3	21.08	13.7	4.3	19.46	12.38	3.0	21.58	14.01	3.6
May 25	18.6	------	7.1	20.9	12.5	12.3	18.4	------	6.4	19.4	------	2.8
May 26	17.5	------	3.7	19.5	------	6.6	18.4	------	4.2	21.2	------	20.7
May 27	------	------	9.1	20.51	------	13.6	19.61	------	8.3	21.61	------	21.0
May 28	18.5	------	6.4	21.8	11.97	20.2	20.4	------	8.9	22.9	------	22.2
May 29	20.2	11.25	14.4	20.7	12.19	13.4	20.2	11.73	11.0	13.13	13.13	6.3
May 30	19.61	12.72	12.8	20.51	13.48	13.4	19.31	12.09	8.1	21.81	13.02	15.7
Average [d]	18.27	11.11	5.3	20.15	13.53	8.1	19.31	13.12	5.3	20.28	14.01	7.3

Date.	Coolie 5.			Coolie 6.			Coolie 7.			Coolie 8.		
	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.	C. Brix.	Per cent polarization.	Alkalinity.
May 8	18.4	14.6	1.9	19.0	13.9	0.7	15.9	10.7	6.4			
May 9	17.4	11.46	1.1	18.4	12.24	3.1	17.6	12.39	7.1	22.2	18.38	7.0
May 10	17.0	8.3	7.6	18.1	14.6	2.9	19.1	9.89	7.8	22.1	12.44	14.5
May 11	17.59	14.92	0.8	19.19	15.51	1.6	17.49	14.29	2.3	18.9	9.45	(c)
May 12	17.09	15.88	0.4	18.69	15.15	3.2	17.59	13.65	2.7	20.0	14.92	6.0
May 13	17.4	11.51	0.5	19.3	15.25	2.2	17.6	13.26	1.1	19.25	11.56	1.8
May 14	17.01	12.85	2.2	17.71	11.97	9.1	16.61	10.75	10.1	19.37	11.66	9.2
May 15	18.2	11.58	6.5	20.6	13.36	10.0	18.7	11.65	9.4	19.67	12.05	4.4
May 16	18.59	11.27	8.3	19.32	12.24	4.2	18.52	11.11	8.7	20.9	12.41	13.2
May 17	17.62	10.83	3.7	20.92	12.26	12.8	18.02	11.58	5.8	21.24	11.49	14.2
May 18	18.94	11.83	7.6	21.64	12.79	14.0	18.54	11.37	8.3	21.9	12.64	26.0
May 19	18.6	12.0	7.7	21.5	13.29	17.0	18.1	11.48	7.9	20.8	12.60	12.6
May 20	18.5	12.59	7.2	21.5	12.19	17.1	18.2	11.48	7.9	21.0	12.17	13.6
May 21	18.14	11.00	5.4	20.9	13.27	13.7	18.7	10.68	10.1	19.54	12.0	4.3
May 22	19.4	12.05	12.2	21.5	12.04	16.8	18.4	11.02	6.1	21.01	11.86	15.7
May 23	17.64	10.14	2.4							21.96	12.07	21.0
May 24	18.96	12.36	4.8	20.98	12.17	13.1	19.08	12.07	4.0	19.68	11.12	6.1
May 25	17.7	10.83	7.4	20.11		14.5	19.1		14.6	19.8	12.8	13.8
May 26	18.0		11.5	20.6		18.0	19.0		10.5	19.21	10.46	9.2
May 27	18.71		12.5	21.11		22.0	18.71		7.3	20.82	11.8	15.4
May 28	20.0	10.28	20.9							20.6	11.71	11.9
May 29	18.6	11.07	5.9							19.1	10.9	3.8
May 30	17.31	11.21	7.2							21.11	11.29	13.2
Average [d]	18.12	11.73	6.3	20.00	13.26	10.3	18.16	11.71	7.3	20.46	12.19	10.81

[a] Neutral. [b] Slightly acidic. [c] Acidic. [d] General average: C. Brix, 19.24; per cent polarization, 12.58; alkalinity, 7.6.

In addition to the fields that were already being tapped when we arrived at Semawang, a new field was started by Maximo, a Filipino tapper in our party. He started the preliminary treatment shortly after our arrival, and three weeks afterward, or more exactly May 9, he was delivering juice to the factory as coolie 8 (see Table 9). He used only lime milk of 50° Brix without any bisulphite. The results of experiments on collection are given in Tables 1 to 5.

Tables 1 and 2 give the results with three different methods of collection; namely, the float method, the smearing method, and the funnel method. In each case three stands were taken. In order to determine the extent to which juice is preserved by each method, we took test-tube samples in the afternoon just before putting on the tuquils, and in the morning after removing the tuquils. The test-tube samples were preserved with toluene, brought to the laboratory within an hour, and analyzed immediately. The average of the two samples, which were numbered 1 and 2, give, approximately, the analyses of the total flow for the period covered. We have noticed that the morning flow contains lower sucrose than the afternoon flow.

A comparison of the results given in Tables 1 and 2 indicates that the smearing method gives slightly better results than either the funnel or the float method. The results also indicate that the tuquil juices collected by any of the three methods are consistently lower in sucrose content than the test-tube samples. This is to be expected, as both the lime added to the juice and the gummy matter that is present in the tuquil samples but not found in the test-tube samples, as well as slight fermentation in the former, tend to lower the percentage of sucrose in the juice.

Table 3 gives the results Wood obtained with closed tin tubes, first using no lime, then adding a gradually increasing amount of lime.

Table 4 gives the results obtained with the cup method of distributing lime. In this experiment, which could be run only three days because of the lack of lime, lime paste was used in the cup. The idea was to use the cup without renewal of the lime, as long as it lasted, thus saving the labor incident upon the cleaning and smearing of the tuquils in the original Gibbs method. As our time and the laboratory equipment were needed in the chemical control of the factory, the experiment was discontinued. The results obtained seem to warrant further experimentation.

Table 5 gives the results of collection of sap with the closed tin tubes compared with the collection with bamboo tuquils. Three coolies were each given about thirty closed tins and were instructed to bring the juices from the tins and from the tuquils separately. Both the tuquils and the tins were smeared with lime-bisulphite mixture. At the time this experiment was being conducted, we ran out of filter paper and some of the samples could not be analyzed. The results of coolie 8 seem to indicate a slight advantage in favor of the tin.

To gain some idea of the variation in composition of the sap from different stands, test-tube samples were collected from a number of stands in different fields. The juices were preserved with toluene as in experiments 1 and 2 (Tables 1 and 2). The results are given in Table 6, and show a general average for test-tube samples as follows: Refractometer solids, 20.3; per cent polarization, 17.04; refractometer purity, 83.94.

It has been remarked that as a rule test-tube samples give higher per cent polarization than tuquil samples and that several factors contribute in lowering the per cent polarization in the latter. How far the sucrose content of the tuquil samples can be made to approach that of the test-tube samples will be largely determined by the experience and care of the collectors and by the adoption of a reliable device for the uniform distribution of lime.

Table 7 shows the results of an experiment to determine the lowest alkalinity that will inhibit decomposition of the sucrose in the sap. The sap used in this experiment was collected directly in clean bottles containing a few drops of toluene. Equal amounts of the thoroughly mixed sap after the removal of the toluene were placed in clean bottles and limed to different alkalinities. It is interesting to note the gradual decrease in alkalinity from day to day, at first only in the samples of low alkalinity, but later even in those with greater alkalinity. Wells and Perkins(4) could preserve sap in strongly alkaline (54 cubic centimeters 0.1 *N* cubic centimeter per 10 cubic centimeters juice) condition without apparent decomposition for as long as one month. Some decomposition may have taken place in the sap, which may have escaped notice, as juices kept by us under their conditions became dark in the course of several days and showed a slight decrease in polarization. As they could obtain white sugar from the sap kept in strongly alkaline condition for a month, the slight decomposition and the deeper color did

not evidently affect the refining quality of the juice. Our experience in Semawang confirms this finding.

Tables 8 and 9 give the composition day by day of the juices collected by the tappers; Table 8 for juices collected during the first part of the season, when the smearing of the tuquils was done by the tappers in the field and when some Chinese coolies were employed; and Table 9 for the second part of the season, when seven Malays and Maximo were employed. The tuquils were then smeared with lime milk in a central station, using a mixture of lime and sodium bisulphite.

No sugar could be made from the juices reported in Table 8. The blank spaces in Table 9 correspond to days when for lack of lime we had to discontinue collection, awaiting arrival of order from Sandakan.

THE MANUFACTURE OF SUGAR FROM THE SAP

The first experiment we ran on the manufacture of sugar from the sap was in the muscovado plant. The juice was evaporated in open pans to a concentration of not over 40° Brix with the purpose of reducing the bulk and thus saving in transportation expenses. Three daily collections were boiled.

A comparison of the purity of the sirup with that of the clarified juice, reveals a great drop in the purity when the juice is boiled in open pans. Coincident with the destruction of sucrose, there was also great darkening of the solution. After the first trials, it was evident to us that sirup of good quality could not be obtained in this way, and that the method destroyed the refining quality of the nipa sap, which is its greatest asset and advantage over the sugar-cane juice.

For the following reasons it was not considered worth while to continue the experiments in the muscovado plant.

1. Transportation by water is relatively cheap, and the saving in handling sirup instead of the sap will be more than offset by the disadvantages.
2. Nipa sap can be preserved efficiently by heavy liming.
3. Heavy liming is not harmful to the refining qualities of nipa sap.
4. Sirup of 40° Brix may still be subject to fermentation after several days' standing.
5. No little investment would be required for the open-pan evaporators.
6. Such method will place in the hands of unskilled labor the carbonation of the sap, an important operation on which the quality of the sugar largely depends.

7. In a muscovado plant, only a crude carbonation apparatus could be used. In such apparatus, the mechanical loss through the formation of foam is very high.

In the centrifugal plant the simplest method of treating the juice was adopted. The juices, after being weighed, sampled, and analyzed for sucrose, were received in a tank. From the reservoir tank the juice was pumped to the carbonating apparatus made from 50-gallon drums and galvanized iron pipes, as shown in fig. 3. The carbonated juice was heated to boiling and passed through continuous settling tanks to the clarified-juice tank from which it was taken into the evaporator and boiled to sirup. The sirup was boiled as in cane-sugar manufacture.

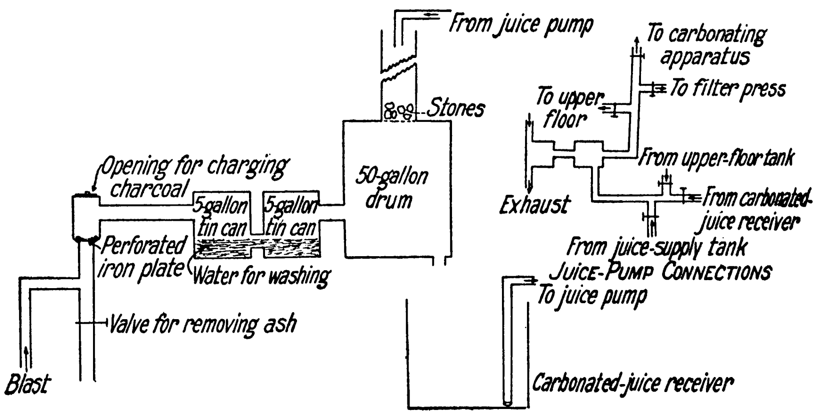

FIG. 3. Diagrammatic arrangement of the carbonating apparatus.

The first run produced a mass that was badly foaming, very viscous, and could not be boiled to the graining point even after fifteen hours. Laboratory examination revealed that it contained a heavy precipitate of gummy matter which would not settle except by the addition of lime. Samples of juice were then taken from the laboratory and treated with different amounts of lime. In juices of alkalinity less than 27 cubic centimeters of 0.5 N per 10 cubic centimeters juice, carbonation to neutrality failed to remove all of the gummy matter. Some form of it remained in colloidal solution and would not settle or separate out even when filtered until after the juice was concentrated to massecuite. Solutions containing a certain amount of these gums when boiled with small amounts of calcium carbonate developed color and the characteristic odor of nipa juice. When, however, the juice was limed to an alkalinity of 27 cubic centi-

meters 0.5 N per 10 cubic centimeters juice, and the gummy matter filtered or strained out, and then the strained juice carbonated to neutrality and filtered, the concentrated filtered juice gave a water-clear, pale yellow liquid that boiled readily with very little foaming. Before adopting the method suggested by our laboratory experiment, we tried once more to carbonate juices of low alkalinity. This time care was taken to allow the clarified juice to settle longer and to send only clear juice to the clarified-juice tank. This second trial resulted in a thick massecuite and a very low yield of sugar. The same difficulties were encountered as in the first trial.

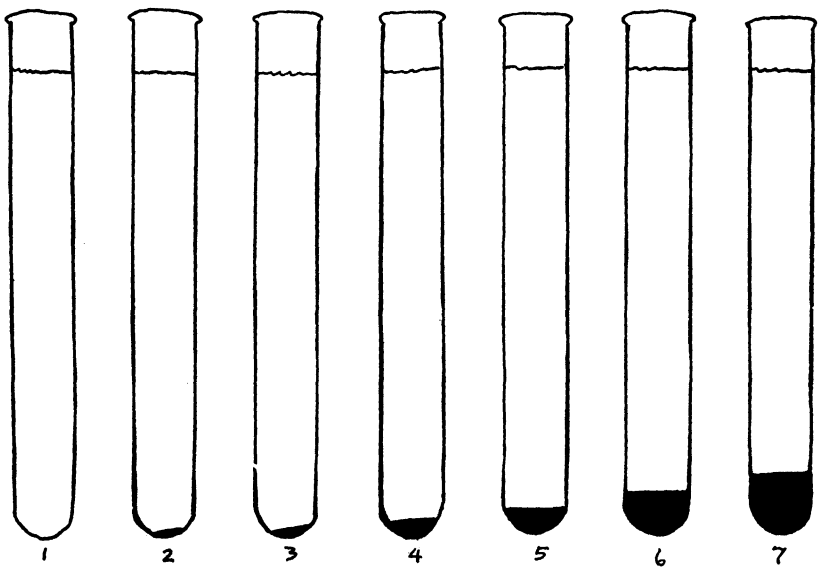

FIG. 4. Relative amount of precipitate formed upon the addition of a graduated increasing amount of lime to nipa sap.

The following method suggested by our laboratory experiments was adopted. The juice, after being weighed, was placed in drums and treated with lime to an alkalinity of 27 cubic centimeters 0.5 N per 10 cubic centimeters juice. It was allowed to settle for several hours and syphoned into a tank from which it was taken into the carbonating apparatus. Carbonation was accomplished by gradually warming the juice as it was being neutralized by the carbon dioxide. When the neutral point was reached, as indicated by the effect of a drop in phenolphthalein solution contained in a test plate, the liquid was brought to the

boiling point and boiled for about two minutes. Then the juice was pumped to a reservoir on the upper floor and allowed to fall by gravity through the filter press. The juice filtered very easily, flowing as if there was no filter cloth in its way; and the precipitate formed a hard granular cake, which did not readily clog the filter cloth. The filtered juice was water-clear, pale yellow, and practically free from gum. The process is represented diagrammatically in fig. 5.

In order to confirm the good effect of heavy liming, we tried once more to carbonate juice with low alkalinity, this time the whole of the carbonated juice was filtered. A difference in

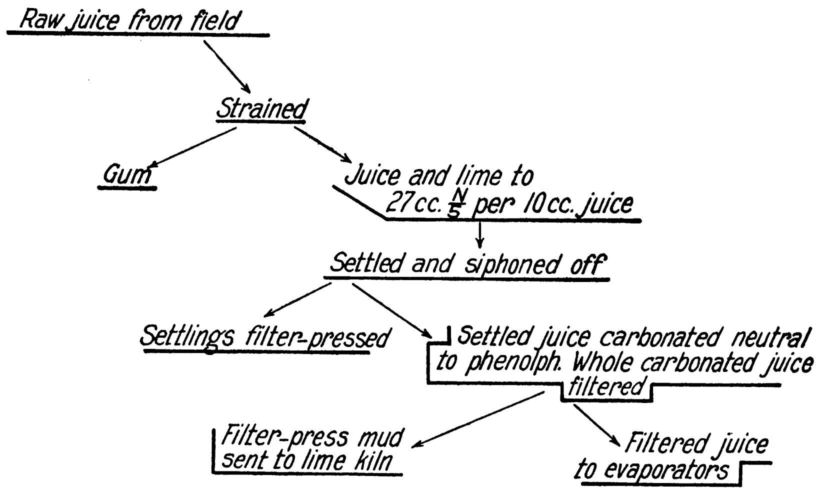

FIG. 5. Method for the manufacture of sugar from nipa sap at Semawang.

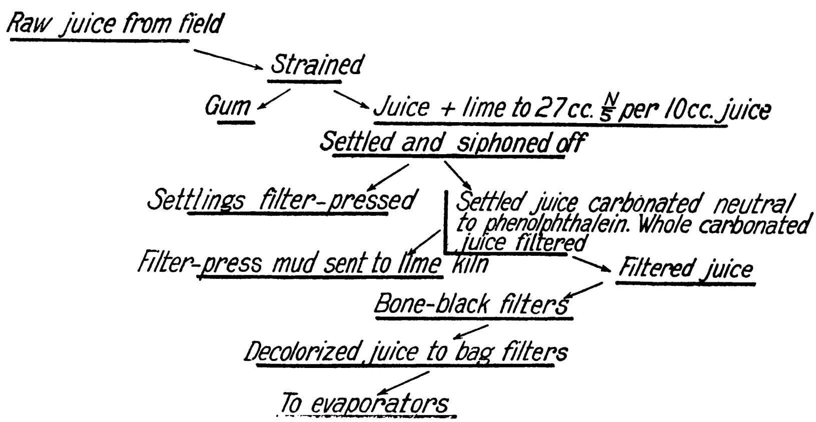

FIG. 6. A proposed method for the manufacture of refined sugar from nipa sap.

behavior between heavily limed and lightly limed juice again became evident on filtration. While the heavily limed juice filtered readily, giving a granular, solid, easily handled precipitate, the slightly limed juice was hard to filter and gave a cloudy filtrate, and slimmy precipitate which clogged the filter in a short time.

We ran two strikes with heavily limed juice, two with slightly limed juice, and a mixed massecuite. In every case the noted difference in behavior between the slightly and the heavily limed juice was observed. Moreover, the sugar made from the heavily limed juice was decidedly whiter than that from the slightly limed juice. The best sugar was made from strike 3. In this case, the cold juice was carbonated until neutral, then it was heated to boiling, boiled for two minutes, and filtered. Table 10 gives the balance of recovery and losses. Table 11 is the daily raw juice weight record. Table 12 is the final run report. Table 13 gives the proximate analysis of the white sugar after it was first dried in the sun. This analysis was made at our laboratory in Los Baños.

TABLE 10.—*Balance recovery and losses for the whole period from May 11 to June 3, 1925.*

Recovery and losses.	Debit.		Credit.	
	Kilos polarization.	Per cent.	Kilos polarization.	Per cent.
Entered in raw juice	431.21	100		
Recovery:				
152.3 kilos sugar in bags at 97.4 polarization			148.34	
15.4 kilos available commercial sugar in A molasses.			14.96	40.67
12.4 kilos available commercial sugar in B sugar.			12.07	
Losses:				
In settlings			12.15	2.82
In filter press cake			3.67	0.85
In final molasses in cans			38.21	8.86
In available final molasses from the A molasses.			59.46	13.79
Mechanical losses in carbonation			80.84	18.75
Mechanical losses in pans and by inversion			61.51	14.26
Total	431.21	100	431.21	100.00

Text fig. 7 represents in diagrammatic form the distribution of the common salt in the various sugar-house products. In the manufacture of sugar from nipa sap special attention seems to be demanded by the presence of sodium chloride in the juice

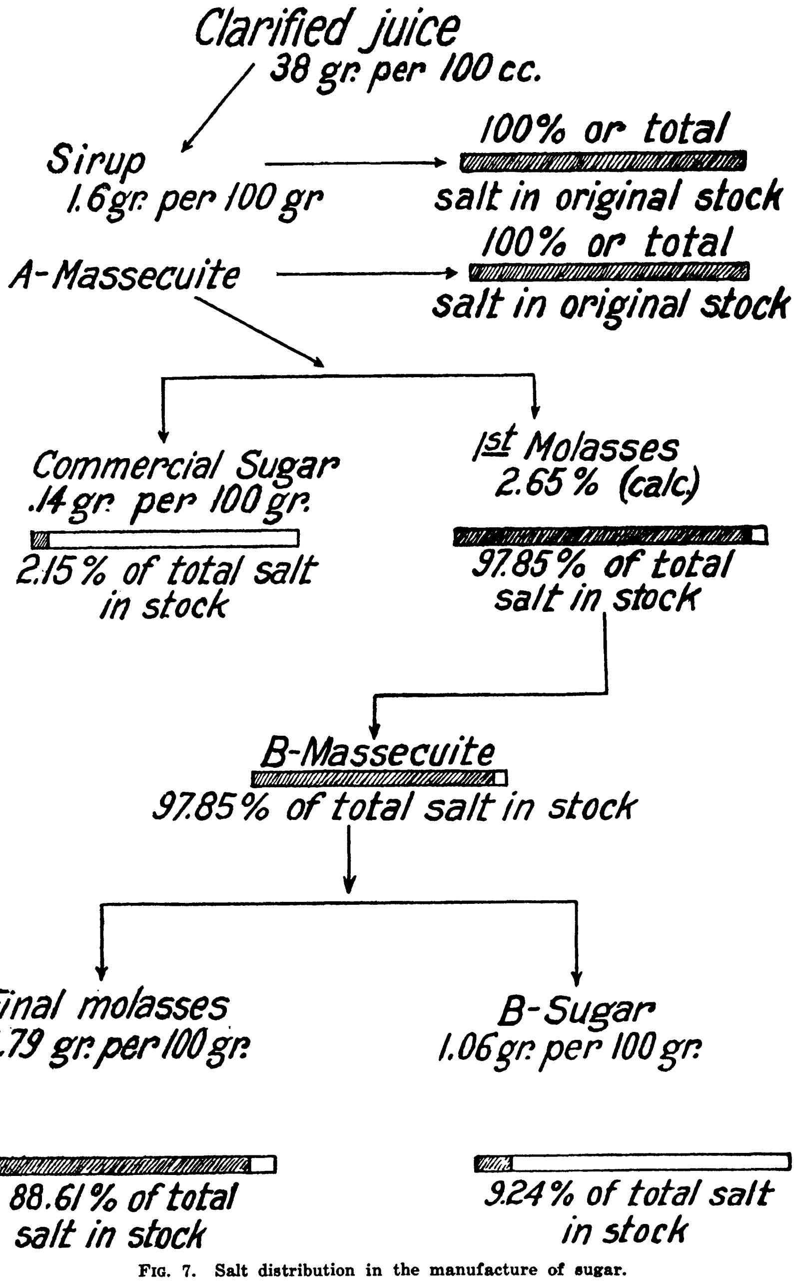

FIG. 7. Salt distribution in the manufacture of sugar.

since this is far above the amount ordinarily found in saccharine juices from other plants. Nipa sap ordinarily contains about 0.37 per cent of sodium chloride, and upon concentration and

crystallization of the sugar, the mother liquor, from which the commercial sugar is separated, is practically a saturated solution of common salt. It is, therefore, not surprising to find that the sugar made may contain from 0.2 to 0.5 per cent salt depending on the grade. Some of the sugar contained as low as 0.15 per cent;[2] this shows that most of the salt may be washed out from the sugar. As the B sugar contains more molasses and therefore a higher percentage of sodium chloride (in one of the B sugars as high as 1.3 per cent), special attention should be paid to its return to the process. When B sugar of such sodium chloride content is used for seed or remelted in the clarified sap, the amount of sodium chloride may gradually increase in the subsequent massecuites and, therefore, in the commercial sugar. If refined sugar is made directly from the nipa sap, returning the B sugar to the process may not be desirable at all. It may be more advantageous to sell it as muscovado sugar.

CHEMICAL-CONTROL PROBLEMS

After an experience of a few days in the analysis of nipa sap it became apparent that Horne's dry lead subacetate method, the most convenient and rapid method universally used in cane-sugar factories, is of no value in the polarization of nipa juices. The lead subacetate, while clarifying the juice to a lightly colored liquid, produces a fine precipitate which passes through the filter paper readily and makes the filtrate unsuitable for polarization. We found that lime in the form of dry calcium hydroxide is the best clarifying agent for nipa juices. One objection to the use of calcium hydroxide in clarifying saccharine juices is its pronounced effect in depressing the polarization of sucrose by the formation of calcium saccharate, a compound with much lower optical rotation than free sucrose. This effect of calcium on the polarization of sucrose may be observed in the increase in purity of the carbonated juice over that of raw juice. While it is possible to determine the per cent polarization in the raw juice by taking the normal weight and removing the lime by a carbonate solution, such a method does not lend itself to the rapid work demanded in the control of incoming juices, in the regular process of manufacture. It is thus apparent that methods of analysis for rapid control work especially adapted

[2] Some of the white sugar analyzed at Los Baños gave as low as 0.06 per cent sodium chloride.

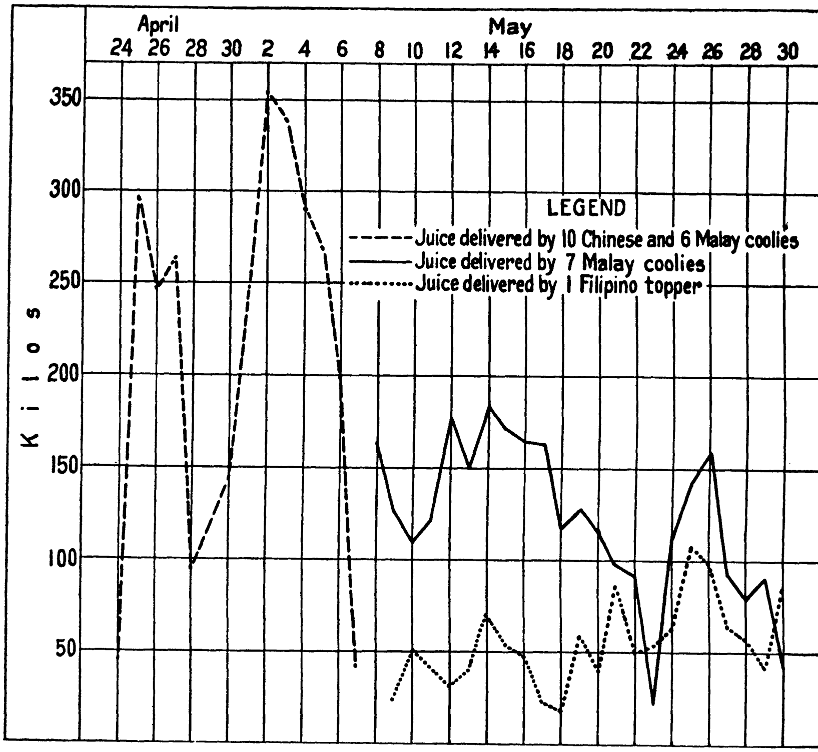

FIG 8. Daily juice weights record.

to nipa juice must be devised and tables made similar to those for Horne's dry lead subacetate method for cane juices.

Although the polarization of raw juices is the best criterion on which to judge the acceptability of juices that are turned in by each coolie, one can realize the impossibility of using it where thousands of coolies are employed in sap collection as in large-scale manufacture of sugar from nipa. Emperical methods of judging the acceptability of juices, which of course may subsequently be supplemented by polarization of group samples, must be devised. One such method is the determination of the alkalinity of the juice. In the course of our work at Semawang, we found that juices which underwent partial fermentation were only slightly alkaline or acidic, and we adopted the scheme of taking a definite volume of the juice collected by each coolie and adding it to a test tube containing a measured amount of acid and a few drops of phenolphthalein. Juices that did not

show any color were set aside. These were then sampled and analyzed. If the percentages of sucrose were found to be above 10, they were accepted, if below, discarded. After a few weeks of experience in judging juices, and after eliminating the possibility of coolies adding salt water, one can judge whether juices are good or poor or very largely fermented by their appearance and formation of froth; foaming, milky surface, and bubbling of the liquid indicating deterioration of the sap.

COMMENTS AND DISCUSSION

Collection of sap.—The collection of the sap should be considered the most important stage in nipa-sugar manufacture since the quality of the sap collected will determine whether the industry will be a success or a failure. A complete understanding of the problems bearing on collection is important.

Gibbs, after careful study of the nipales around Manila Bay, estimated that 30,000 liters of sap may be obtained per hectare of 750 producing stands per season of ninety days. This is at the rate of 40 liters per stand per season of ninety days, or about 0.44 liter per day. Out record at Semawang tends to show that this estimate is also applicable to the nipales there. Table 11 gives the daily weight of juices during the whole period of collection. Disregarding the first part of the period, from April 24 to May 7, and only taking into consideration the period from May 8 to May 30, we find that during this period the seven Malay coolies delivered 2,828.8 kilograms of sap. This amount collected from 240 trees shows, therefore, a rate of production of 0.513 kilogram per stand per day. From May 9 to May 30, coolie 8 turned in 1,182.5 grams. He was handling 110 trees. His record follows: Days of collection, 21; trees tapped, 110; sap collected, 1,182.5 kilograms; sap per tree per day, 0.513 kilogram.

It is to be noted that the Malay coolies were collecting sap from stands that had been tapped for over three months, while Maximo was tapping stands that still had very long stumps, and which one may consider to be at the beginning of the season.

The Malay coolies used in the collection of sap were under contract with the Semawang alcohol plant at 50 cents, Bornean money, a day. They were handling about 34 nipa stands each and were putting in about three hours work a day. The superintendent of Semawang asserted that he did not know of any way to make the Malays handle more than that number of

TABLE 11.—*Daily raw juice weight record.*

Date.	Kilograms.	Date.	Kilograms.
April 24	45.4	May 26	158.7
April 25	295.7	May 27	93.4
April 26	246.1	May 28	79.4
April 27	266.2	May 29	91.1
April 28	94.5	May 30	42.3
April 30	145.2		———
May 1	244.6	Total	2,828.8
May 2	353.3	May 9 [b]	24.3
May 3	337.2	May 10	50.1
May 4	290.3	May 11	([c])
May 5	267.3	May 12	32.0
May 6	195.7	May 15	39.1
May 7	40.9	May 14	69.0
	———	May 15	54.6
Total [a]	2,822.4	May 16	48.9
May 8	164.1	May 17	24.2
May 9	127.0	May 18	18.5
May 10	110.2	May 19	58.7
May 11	122.5	May 20	41.6
May 12	178.0	May 21	86.4
May 13	149.9	May 22	50.5
May 14	182.6	May 23	54.2
May 15	171.0	May 24	63.0
May 16	165.0	May 25	107.9
May 17	162.7	May 26	99.0
May 18	116.6	May 27	64.0
May 19	128.2	May 28	59.4
May 20	117.2	May 29	42.0
May 21	98.3	May 30	85.1
May 22	93.5		———
May 23	22.4	Total	1,182.5
May 24	110.8	Grand total	6,833.7
May 25	143.9		

[a] The record for May 8 to 30 is for seven Malay coolies.
[b] The record for May 9 to 30 is for coolie No. 8.
[c] Discarded.

trees. They were unable to obtain satisfactory results with the Malay and Chinese coolies for work in nipa swamps.

The Filipinos, who previous to our arrival worked at Semawang, were turning in several times the amount of sap collected by the Chinese or Malay coolies. Mr. Wood calculated that a Filipino tapper may turn in as much as 90 gallons of sap for alcohol manufacture a day. This would hardly be possible for sap for sugar manufacture, because of the necessity of cleaning the stumps and frequently changing the lime in the tuquil and

the tuquil itself. As the yield of sap per tree varies in different fields, and from day to day, and with the advance of the season, a safer way of estimating the average amount delivered by one tapper per day would be on the basis of number of stands that can be handled by the tapper, rather than by the amount of sap delivered as determined in an observation lasting only a few days. Many observations have been made elsewhere of the variation in flow of sap from nipa stands and a general average per stand to cover a 90-day season given.

Other factors besides the variation of flow of sap must be taken into consideration. In collection on a commercial scale, tappers should be instructed to throw away partly fermented sap; some sap will be spilled in handling, or lost through the work of monkeys or otherwise. All of these must be taken into consideration. A safe and conservative estimate may be made only by carrying out the observations with a number of coolies handling several hundred trees throughout one nipa season and under actual working conditions.

Other factors that tend to lower estimates obtained in experiments in a grove not systematically developed for collection on a large scale are lack of trails and of a system of canals, and the fact that coolies still have to carry the sap to the plant, and lack of organization and disregard of the principle of the division of labor. Tappers who do nothing but clean and tap stands, working in coöperation with another gang whose sole duty is to collect and deliver sap to storage stations, will undoubtedly be able to handle in one day more than the estimate of 210 trees used in this report.

The figures given by Gibbs and those obtained by us at Semawang agree within narrow limits. For purposes of collection, we are assuming an average of 45 kilograms of sap per stand per season of ninety days.

The average sucrose content of sap collected by the coolies was 12.58 per cent. This is in agreement with the findings of Eaton and Dennete,(6) who recommend that, for purposes of sound estimate, 12.5 per cent sucrose in the sap should be used. In making our estimates, we also use 70 per cent for boiling-house recovery (see Table 12).

Considering the fact that the quality of sap depends entirely on the interest of the tapper in his work and considering the kind of labor used in nipales, we believe that the only way to insure good quality of sap is by adopting the share system in

TABLE 12.—*Final run report; June 3, 1925.*

	Actual.	Calculated assuming 70 per cent recovery, and 4 per cent mechanical loss.[a]
Juice entered into manufacture:		
Juice delivered ..... Tonnes	3.4422	3.4422
Sucrose ..... Per cent	12.53	12.53
Juice per ton sugar ..... Tons	22.586	11.323
Sugar per ton juice ..... Piculs	0.698	[b] 1.39
Sugar manufactured:		
Polarization ..... Per cent	97.4	99.0
Moisture ..... do	.....	[c] 0.18
Excess moisture ..... do	.....	11.38
Clarity	.....	([d])
Ash ..... do	.....	[c] 0.19
Tonnes	0.1523	0.3040
Lime used:		
Calcium oxide (CaO) per ton juice ..... Kilos	130.0	130.0
Press cake:		
Juice ..... Per cent	3.3	.....
Polarization ..... do	3.2	3.2
Settlings:		
Juice ..... do	2.9	2.9
Polarization ..... do	12.2	12.2
Final molasses:		
Brix	83.64	83.64
Gravity purity	57.8	57.8
Total produced ..... Tons	0.076	0.231
Per ton sugar ..... Gallons	[e] 202.4	139.7
Sirup:		
Brix	60.8	60.8
Apparent purity	80.6	80.6

[a] The boiling-house recovery of 70 was assumed on the following consideration. The purity of the best final molasses we obtained was 57.8. This was boiled from a molasses of rather high purity and which came from the juice that was slightly limed. The B molasses we obtained from the heavily limed juice had a purity of 61.0. We could expect a purity of 50 in the final molasses obtained from this A molasses. Pratt and coworkers were actually able to obtain final molasses of 50 purity from nipa sap. The theoretical recovery for sirup of 80 purity and final molasses of 57 is 68.7. The theoretical recovery on sirup of 80 and final molasses of 50 is 76.6. We arbitrarily took 70 lying between these two figures as a conservative percentage of recovery to be used for purposes of calculating probable returns.

[b] The piculs per ton juice was figured on a sugar polarization of 99.0, the polarization of sugar after drying in the sun.

[c] The samples of sugar were analyzed at Los Baños after they were dried in the sun.

[d] Water clear.

[e] Includes available B molasses in A molasses in stock.

collection. Our experience with Chinese coolies in Semawang, though brief, has convinced us of the advisability of adopting this method. In central practice in the Philippines, it has been found that the fifty-fifty contract is a satisfactory distribution

of sugar, and is most generally used. For purposes of calculation, we, therefore, adopt the fifty-fifty contract.

Calculation.—Forty-five kilograms of sap at 12.5 per cent sucrose, 70 per cent boiling-house recovery, will give 3.94 kilograms of sugar; 50 per cent of this is 1.97 kilograms of sugar per season per tuquil. This is white sugar at an estimated value of 5 cents a pound or 22.4 centavos per kilogram. Therefore, the value of the sugar corresponding to one tuquil per season is 44.34 centavos.

In a series of observations made by one of us in the course of our work, we found that it took, on the average, two minutes per stand to collect sap, wash the stand, tap, and attach the new tuquil. Thus, a man working seven continuous hours will handle 210 stands in one day. There are laborers who can handle more, and others, less, but we can consider 210 a fair and conservative average; 210 stands at 43.34 centavos will give the tapper 91.40 pesos in ninety days or at the rate of about 1 peso per day. This will prove attractive to Filipino laborers, provided the cost of lime and other extra expenses are not added. If the tuquils used are made of bamboo, the laborers themselves can make them. The bamboo tuquils cost 3 to 3.5 centavos and if cared for properly will last indefinitely.

We believe that the bamboo tuquil is not likely to be replaced by more elaborate containers. Tubes made of tin or any convenient material different from bamboo would probably cost not less than 30 centavos, 70 per cent of the return per stand. Those used at Semawang cost 40. Even assuming that the life of the tuquil is four years (if it is made of tin it may not last two years) the increased return will not compensate for the cost. On the other hand, the cup shown in fig. 1, which would materially reduce the consumption of lime can be made from a discarded food tin at a cost of less than 5 centavos.

Summary.—Yield of sap per stand per season of ninety days, 45 kilograms; sugar per stand per season (12.5 per cent sucrose in sap, 70 per cent boiling-house recovery), 3.94 kilograms; share of the collector, 50 per cent; value of collector's share at 5 cents a pound (white sugar), 44.34 centavos; 210 trees per season of ninety days will, therefore, return 91.40 pesos, or about 1 peso per day.

Amount of lime and bisulphite needed.—Trials with the smearing method give on the average a dry-lime consumption per tuquil per day of 100 grams. This is at the rate of 19.45

per cent of the weight of the juice. Only 1.5 to 2 per cent is left in the sap. The rest goes to waste. Considering that in the carbonation process used in twenty factories in Java the amount of lime required is only 3 per cent of the weight of the cane, the great necessity of improving collection with the view to reducing the amount of lime used will be realized.

In addition to lime, and during the last weeks of collection, sodium bisulphite must be used. With the smearing method this will amount to about 8 grams per tuquil at a cost of about 0.8 centavo. With the cup method this may be reduced to 2 grams per tuquil at a cost of 0.2 centavo.

Summarizing, it may be said that any improvement in the container for the sap must be inexpensive, of the simplest kind, and capable of adjustment in a few seconds.

In reducing the amount of lime used in collection, the tendency should be to cut down the waste and not the amount that actually goes into solution in the sap. The best preservative for the sap is strong alkalinity. Table 7 shows that an alkalinity of less than 0.4 gram calcium oxide (CaO) per 100 cubic centimeters allows the juice to decompose gradually, but that an alkalinity close to 1 per cent will preserve the juice for many days. For best defecation, an alkalinity of 1.5 per cent is required. The juice may be kept at an alkalinity of 1.51 per cent for many days without any danger. The alkalinity obtained in the smearing method as shown in Tables 8 and 9 is only around 0.7 per cent so that sap collected by this method had to be treated with more lime.

The possibility of keeping strongly limed sap without deterioration for many days has an important bearing in collection, and may avoid for the nipa-sugar industry many of the vexing questions that are inevitable in the harvesting of sugar cane. To simplify collection, nipa groves may be divided into districts which may be provided with large storage tanks for sap. The sap may be taken to the factory after a sufficient amount has accumulated.

Sampling stations.—From each district samples of sap must be collected and analyzed for sucrose and alkalinity. The analyses serve as checks on the work of groups of coolies in the field, and for purposes of sugar distribution.

Liming stations.—Stations where lime milk may be prepared and where tuquils may be cleaned and smeared with lime, should this method be adopted, will be necessary during the first days

of the enterprise and wherever inexperienced workers are used. Standardization of lime milk used, and of the lime-milk-bisulphite mixture, will be important.

System of trails.—To facilitate the work of coolies, a system of trails in groves on high river banks or a system of canals in groves on low river banks will be necessary.

The use of pipes in delivering juice to the factory will, in our opinion, be much more expensive than transporting the juice by water. Also, when juices are not limed to a point where the gums contained in the sap are completely precipitated, and if they are not strained out, there will be fouling of the pipes which will be sufficient reason to discard the possibility of their use.

Handling of incoming juices in the factory.—Text fig. 6 shows in diagrammatic form a process of manufacture that we would recommend for nipa sap. The juice may be stored in tanks, of which there must be several in the factory, and is sampled and analyzed for sucrose and alkalinity, and measured or weighed for the control record. After being weighed and measured the juice is strained through fine metallic strainers provided with automatic scrapers. This straining is necessary to remove the gelatinous gummy matter which ordinarily accompanies the sap and, if not removed, may give greater color to the juice treated with lime to strong alkalinity. The strained juice is limed to 27 cubic centimeters 0.5 N per 10 cubic centimeters juice, then settled or immediately filter-pressed, the filter-press juice being sent to the carbonation tanks. It is essential to provide the carbonation tanks with tall sides as the juice foams badly on carbonating. The juice must be carbonated in the cold, and as soon as it becomes neutral to phenolphthalein, it must be heated to boiling and boiled for one to two minutes. The filter-press cake may then be washed sparingly with water and the washings used in slaking the lime, a practice which will help reduce the amount of water to be evaporated. Nipa sap treated in this way is practically free from gum, and may be passed through bone-black filters, and then through bag filters, for the direct production of refined sugar.

In designing plants for work with nipa sap, the most efficient vacuum pumps should be used since high vacuum is essential in boiling both the thin juices and the sirup. Other equipment for the handling of refined sugar, such as the granulator, must naturally be included in the plant.

Carbonating tanks.—The alkalinity of the sap for best defecation is about 1.51 per cent calcium oxide by weight, which is approximately the same as that in sugar-cane juice for factories using the carbonation process. Therefore the same standards as to size of tanks, etc., may be used.

Lime kilns.—When the smearing method is used the lime kilns must be of such size as to supply 20 per cent of dry calcium oxide on the weight of the sap. If the cup or a similar method is used, the amount of lime may be reduced to 5 per cent. Deerr [3] estimates the amount of lime used in carbonation to be 3 per cent on cane. It may be roughly stated that the capacity of lime kilns for nipa sap using the cup method should be from $\frac{4}{3}$ to $\frac{5}{3}$ times that for sugar cane.

Filter presses.—In a test at Semawang we obtained the following data: Filtering area of press, 5.47 square feet; carbonated sap with the precipitate passed in one hour, 305.1 kilograms. This gives a filtering area of 17.9 square feet per ton hour. The filtering area for settlings would be about the same so that the total filtering area per ton-sap-hour would be about 35.8, which is one-third of that for sugar-cane juice. In the latter case, only the scums and settlings are filtered, while in the former, the whole carbonated juice is passed through the press.

ESTIMATE OF COSTS AND RETURNS

Cost of fuel.—For the generation of steam for power, juice evaporation, and other purposes, firewood will have to be used. Firewood per ton sap was figured as follows:

	Kilograms of steam per ton of juice.
Power and evaporating	411.2
Evaporating of extra water added in heating, and sundry	34.1
Loss by radiation	2.5
Drying in granulators	1
Unforeseen	2
Total	450.8

Allowing 5 kilograms steam per kilogram of firewood of 10,000 British thermal units the firewood consumption for the evaporation of one ton of sap will be 90 kilograms.

[3] Cane Sugar, new ed. 285.

The firewood to be used in the lime kilns may be estimated at 57 kilograms per ton of juice. Adding this amount to that required in the evaporation of the sap a total of 147 kilograms of firewood per ton of juice will be needed.

The cost of firewood (bakawan) delivered at Semawang is 33 centavos per 100 kilograms, so that the cost of fuel per ton of juice would be 48.5 centavos. Sap produces 1.39 piculs per ton, and cost of firewood per picul would be 33 centavos. Any extra power needed may be generated from the alcohol from molasses.

Lime.—Lime was figured, on 5 per cent of the weight of sap, to cost 15 pesos per ton. Using the smearing method, which would require 20 per cent of lime on the weight of sap, the cost of lime per picul of sugar would be 2 pesos. This high cost of lime would be prohibitive and would exclude the use of this method on a commercial scale. With the cup method, using a total of about 5 per cent of lime on weight of sap, the cost of lime per picul of sugar would be 50 centavos.

The estimated cost of 15 pesos a ton for lime may be reduced to a very low figure by the return of the filter-press cake from carbonated juice. Only a small percentage of the raw material need be replaced from time to time, for the amount lost in the field and that which goes into solution in the sap. Mr. Wood gave us the probable cost of raw materials of which there is said to be an almost inexhaustible supply at Kinabatangan River, near Sulcan or Bilit about 100 miles from Semawang. The transportation of the lime to Semawang would cost 2.30 pesos per ton. Including quarrying the cost of the raw material would not be over 4 pesos per ton. The estimate of 11 pesos per ton for the handling in the factory seems to be very conservative.

TABLE 13.—*Analyses of the nipa sugars.*

Sample.	Sodium chloride (NaCl).	Moisture.	Ash.	Polarization.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
A sugar; unwashed sugar, strike 1	0.55	1.17	1.11	95.1
Sundried A sugar; first sugar made with little washing	0.21	0.74	0.24	97.9
Sundried A sugar; washed sugar made from heavily limed juice	0.06	0.45	0.24	99.1
Sundried A sugar; washed sugar made from slightly limed juice	0.07	0.52	0.21	98.9
B sugar	1.34	4.34	3.15	85.6

Cost of bisulphite.—The cost of bisulphite would be 5 centavos per picul of sugar made.

Final molasses.—Estimated gallons of molasses per ton of nipa sugar is 139.7, which is about twice as much as the average per ton from cane.

The total fermentable sugar in the nipa molasses per unit weight will be approximately the same as for cane molasses, so that the only difference to be taken into consideration in comparing the two is in the amount produced per ton of sugar.

A comparison of probable operating expenses for cane- and nipa-sugar manufacture is given in Table 14. The figures for cane sugar were obtained from the published statements of the Philippine National Bank Sugar Centrals Agency.

TABLE 14.—*Comparison of probable operating costs of nipa with those of cane-sugar manufacture.*

	Cane; 1.69 piculs sugar per ton cane.	Nipa; 1.69 piculs sugar per ton sap.	Nipa; 1.39 piculs sugar per ton sap.
Ordinary expenses:	*Pesos.*	*Pesos.*	*Pesos.*
Administration	0.38	0.38	----------
Milling	0.47	----------	----------
Fabrication	0.64	0.64	----------
Transportation	0.97	0.97	----------
General repairs [a]	0.33	0.35	----------
Property department	0.09	0.09	----------
Sugar-sales expenses	0.20	0.20	----------
Ordinary off-season expenses	0.57	0.57	----------
Prorata; Philippine Sugar Centrals Agency	0.17	----------	----------
Unusual expenses:			
Factory	0.07	0.07	----------
Floating equipment	0.04	----------	----------
Tie replacements	0.28	----------	----------
Inventory shortages	0.23	0.23	----------
Total	4.44	3.50	4.25
Additional expenses for nipa:			
Firewood	----------	----------	0.35
Lime	----------	----------	0.50
Bisulphite	----------	----------	0.05
Total	4.44	3.50	5.15

[a] Expenses for handling bone black, bag filters, and granulators are included in general repairs as the cost of repairs in the nipa plant would be much less than in the cane plant, mills being absent in the nipa-sugar house.

	Pesos.
Cost of central's share of nipa sugar	10.30
Estimated New York price of refined sugar per picul at 10 centavos a pound	13.90
Probable net balance	3.64

The returns from molasses are not included in the estimated balance.

Investment.—If depreciation, interest, and dividends are 30 per cent, a possible capitalization for a 1,000-ton house, operating in a season of 100 days will be approximately 1,700,000 pesos.

The nipa season at Semawang may be extended to 180 days, and possibly to 300 days. A longer season will make it possible to operate the plant on one-half of the probable net balance indicated.

Simpson estimated the probable cost of a 1,000-ton house, including quarters for the laborers and personnel, at 1,000,000 pesos.

It may be desirable to start with a 100-ton house. The foregoing estimates may be used, after allowing an increase in the operating expenses, which will be higher in a small sugar house.

A 100-ton house will require about 1,000 men in the field, about 100 men in the factory, and about 400 hectares of nipales.

COMPARISON BETWEEN THE CANE-SUGAR AND THE NIPA-SUGAR MANUFACTURE

The manufacture of sugar from nipa has the following advantages over that from cane:

1. The crop will be sure every year, unaffected by locust, typhoon or unfavorable weather conditions, or fire.
2. It would be perfectly possible to manufacture refined sugar directly from the sap by a simple process.
3. The absence of a mill plant makes the factory simple and easier to operate with less repair expenses than a cane-sugar factory.
4. The sap, which may be kept for days after it is made alkaline, can be easily transported by water.
5. The sugar season may be extended to ten months or at least six months which will enable the manufacturers to operate on a very narrow margin of profit.
6. There is still a possibility of improving the quality ratio of the sap and thus materially lowering production cost per picul.

There are the following disadvantages in nipa-sugar manufacture compared with cane-sugar manufacture:

1. The quality of juice obtained is dependent on the kind and disposition of the labor used.
2. The amount of labor required in the handling of nipa sap would be much greater than in the cane. For the production and harvesting of 30 tons of cane a conservative estimate of 70 man-days would be required. For the handling of 30 tons of nipa,

153 man-days will be required. Of course, less men would be required in a nipa-sugar factory, but the difference would be comparatively small and will hardly affect the large difference in the man-days labor in the field.

3. The necessity of buying firewood or other fuel to run the nipa-sugar factory may prove to be a source of trouble as the neighboring forests become depleted; a system of reforestation must necessarily be adopted, unless coal or crude oil can be used. However, the Conservator of Forest of the State of North Borneo believes that a 25-year supply can be assured for Semawang.
4. The absence of invert sugar in the nipa sap causes the purity of final molasses made from it to be much higher than in cane molasses, thus making the quality ratio of the nipa sap decidedly higher than of cane, under similar conditions.
5. The nipa is not entirely free from enemies. Parasites may affect the productiveness of the stand by attacking the leaves. The fruits find enemies in wild hogs and monkeys. The latter may prove particularly destructive to the stands that are being tapped as they are wont to come around on occasions and pull off the tuquils from their position, throwing their contents away. We have had trouble with them at Semawang. At times as many as 50 per cent of the tuquils in several fields were emptied by monkeys.

SUMMARY AND CONCLUSIONS

1. Sugar can be manufactured from nipa sap with a reasonable margin of profit.

2. The problems of collecting sap should receive careful attention. The smearing method would not be commercially possible except when the price of sugar is high. Methods that would use less lime but which are just as simple and inexpensive, such as the use of tin cups with baffle plates, should be further studied and tried.

3. Collection should be on a share basis in order to induce the collector to take interest in turning in the greatest amount of sap of the best possible quality.

4. The adoption of a fifty-fifty contract similar to the system generally used in the cane industry would be most convenient.

5. A method of manufacture for the direct production of refined sugar from nipa sap is proposed.

6. Estimates of costs and profits are also given.

7. It is recommended that a 100-ton house be tried first in order that both the field and the technical personnel may acquire experience in the handling of nipa juices.

8. It is necessary to promote the study and investigation of certain chemical problems in the nipa-sugar manufacture, mainly in relation to the chemical control of the sap.

9. Under experimental conditions at Semawang, nipa sap of 12.53 per cent sucrose content was obtained. The lowest purity of B molasses given by an A molasses of 69 purity from a slightly limed juice was 57.8. It should be possible to exhaust the molasses to a purity of 50.

10. With a sucrose recovery of 70 per cent, a polarization in sugar of 99.0, and 4 per cent sucrose in mechanical losses, the sap obtained at Semawang gives a quality ratio of 11,323 and 1.39 piculs sugar per ton sap.

11. A table of comparison of operating costs of nipa-and-cane-sugar manufacture is given.

IMPORTANT LITERATURE ON NIPA AND NIPA SUGAR

1. CONRADO, ANTONIO. Estudio de la planta llamada "nipa" de se cultivo y de sus propiedades, por Antonio Conrado y Enrique Zobel y de Ayala (1906).
2. GIBBS, H. D. The alcohol industry of the Philippine Islands. The nipa palm. Philip. Journ. Sci. § A **6** (1911).
3. PRATT, D. S., L. W. THURLOW, R. R. WILLIAMS, and H. D. GIBBS. The nipa palm as a commercial source of sugar. Philip. Journ. Sci. § A **8** (1913).
4. WELLS, A. H., and G. A. PERKINS. Recent improvements in nipa-sugar manufacture. Philip. Journ. Sci. **20** (1922).
5. ANNETT, H. R., and others. Memoirs Dept. Agr. in India, chem. ser. **2** (1913) 281–389; **5** (1918) 68–116.
6. The Malayan Agricultural Journal **11**, No. 3 (March, 1923). The Department of Agriculture, F. M. S. v S. S. Kwala Lumpur.
7. The Malayan Agricultural Journal **11**, No. 2 (February, 1923). The Department of Agriculture, F. M. S. v S. S. Kwala Lumpur.

ILLUSTRATIONS

TEXT FIGURES

DESCRIPTION OF A NEW PHILIPPINE SHARK

By ALBERT W. HERRE
Of Stanford University, California

HEMIGALEUS MACHLANI sp. nov.

Teeth $\frac{21}{40}$; upper teeth larger, oblique, broad-based, with a long sharp point and five or six denticulations on the concave cutting edge; three middle rows small, erect, simple; lower teeth small, acute, slender, smooth, nearly erect, the last seven rows on each side very much reduced; spiracle hardly half an eye diameter behind eye, much larger than pores; head depressed anteriorly, much wider than high, a trifle less than one-fourth the length; length of snout more than 1.8 times width of arched mouth; length of mouth 1.6 times its own width; labial folds on both jaws at the angle of the mouth, the upper about half the length of the mouth; the lower fold a trifle more than half the length of the upper; eye equal to width of gill openings; nostrils nearer end of snout than angles of mouth, with a triangular lobe over the inner one; pectoral falciform, pointed, a little more than twice as long as broad, extending below middle of dorsal; caudal less than distance between dorsals, nearly 3.6 times in length; the subcaudal lobe pointed; origin of anal behind that of second dorsal, which is larger than anal and two-thirds as large as first dorsal.

Color uniform gray, becoming yellowish white underneath; fins with a reddish or violaceous tinge, more or less pale-edged, the tip of both dorsals whitish.

Type.—No. 11429, Bureau of Science collection; a fine specimen, 773 millimeters long without the caudal, collected by A. W. Herre at Jolo, Sulu Province, Philippine Islands.

I take pleasure in naming this well-differentiated species after my esteemed friend Mr. Perry L. Machlan, of Sitankai, who has been of great assistance to me in my study of the fishes of the Sulu Archipelago.

BAKER'S ENTOMOLOGICA MALAYANA

THE BRACONID GENERA FORNICIA BRULLÉ AND ODONTOFORNICA ENDERLEIN

By R. A. CUSHMAN

Of the Bureau of Entomology, United States Department of Agriculture

In 1846 Brullé [1] published his genus *Fornicia,* based on a specimen of undetermined sex from Brazil. He assigned the genus to his group Cryptogastres, which corresponds approximately to the subfamilies Sigalphinæ (= Cheloninæ of Ashmead) and Triaspinæ (= Sigalphinæ of Ashmead.).

Enderlein's *Odontofornica* [2] was described without indication on the part of its author as to its natural position. It was based on two specimens from Formosa.

Ashmead [3] described his *Fornicia annulipes* from a single male specimen from Manila, Philippine Islands, referring the genus to the Sigalphinæ. This specimen is in the United States National Museum. It is certainly an *Odontofornica.*

Szépligeti,[4] in recording *Fornicia clathrata* Brullé from Java, placed the genus in the Triaspinæ. As pointed out by Enderlein, this is probably a misdetermination.

Cameron [5] records *Fornicia clathrata* Brullé as a parasite of *Sibine bimacula,* and refers it to the Triaspinæ.

Bodkin [6] records *Fornicia clathrata* Brullé as a rather rare parasite emerging from half-grown larvæ of *Sibine fusca* Stoll in the coast lands of British Guiana. He places it in the Cheloninæ.

The placing of this group in the Sigalphinæ and Triaspinæ is one of the many illustrations of the ascribing of too much importance to purely adaptive or anomalous characters and the overlooking of the less conspicuous but really significant char-

[1] Hist. Nat. Ins. Hym. 4: 511, pl. 44, fig. 3.
[2] Ent. Mitt. 1 (1912) 260.
[3] Can. Ent. 37 (1905) 7.
[4] Notes Leyden Mus. 29 (1908) 226.
[5] Journ. Roy. Agr. & Comm. Soc. Brit. Guiana 1 (1911) 319.
[6] Trans. Ent. Soc. London 1917 (1918) 318.

acters. The fusion of the basal tergites into a carapacelike structure beneath which the other tergites are hidden occurs in many groups of Hymenoptera, the enumeration of which is unnecessary here.

I have not seen a specimen of *Fornicia clathrata,* so all of my remarks are based on *Odontofornica,* but Brullé's description and figure render it certain that the two are closely allied if not actually congeneric.

Except for the peculiar structure of the abdomen, all of the more important characters ally this group with the Microgasterinæ, where it is most closely related to the genus *Apanteles.* It resembles the last-mentioned genus in general conformation of the head; the medially impressed postvertex and upper occiput with the resulting interruption of the occipital carina; the hairy eyes; the apically truncate clypeus with exposed labrum; the 18-jointed antennæ with the flagellar joints constricted in the middle; the general conformation and structure of the thorax, which, however, provides most of the characters by which the genera are separable; the large hind coxæ, stout femora, compressed hind tibia and tarsus, and ventrally carinate basitarsus; and the venation of the wings. Especially striking in the similarity in the venation is the flexion of subcostella toward mediella and the obsoletely indicated interradiella and closed first cubitellan cell.

From *Apanteles* the genus *Odontofornica* differs principally as follows: Head very small, little more than half as broad as the thorax; mesoscutum with a more or less distinct median carina; scutellum elevated at apex and with an apical toothlike projection which is sometimes bifid; propodeum with the five basal areas distinctly defined; first three tergites fused into a broad, strongly arched, coarsely rugose "carapace," beneath which the remaining tergites are hidden.

Twelve specimens of *Odontofornica* in the United States National Museum, seven from the collection of the late C. F. Baker, represent apparently six species, separable as follows:

Key to the species of Odontofornica Enderlein.

1. Scutellum bidentate at apex; postscutellum medially elevated into a more or less spinelike process .... 2.
   Scutellum unidentate at apex; postscutellum not especially elevated.. 4.
2. Mesoscutum finely punctate throughout, the median carina weak.... 3.
   Mesoscutum coarsely, rugosely punctate in positions of notauli and around margins, elsewhere sparsely punctate and shagreened, the median carina strong .... *tagalog* sp. nov.

3. Temples seen from above and cheeks from in front slightly convex. *arata* Enderlein.
   Temples from above and cheeks from in front perfectly straight. *penang* sp. nov.
4. Pronotum medially impressed and triangularly produced on each side of middle .... 5.
   Pronotum not as above.......... *borneanus* sp. nov.
5. Mesoscutum flattened medially but not distinctly impressed, the median carina very strong but not much higher than thick. *annulipes* (Ashmead).
   Mesoscutum longitudinally impressed on each side of the median carina, which is much higher than thick.......... *moronis* sp. nov.

ODONTOFORNICA ARATA Enderlein.

Odontofornica arata ENDERLEIN, Ent. Mitteil. 1 (1912) 261.

Before me are two males, one each from Kankau (Koshun), Formosa (H. Sauter) and Yeung Kong, China (C. W. Howard), which differ practically only in color of legs, the Formosan specimen having them largely red. In his description of the species Enderlein mentions this color variation.

The wings in the male are very faintly infumate apically. Face finely, densely punctate, opaque; vertex on each side of median polished depression transversely striate; temples and cheeks rugulose punctate, weakly convex; pronotum flattened and opaquely punctate medially, not triangularly produced on each side of middle; mesoscutum densely finely punctate, opaque, positions of notauli and prescutellar area somewhat but not conspicuously more coarsely and densely punctate, median carina weak; scutellum apically bidentate; postscutellum dentate; mesopleurum, except speculum, and mesosternum finely densely punctate, opaque; abdomen very broad, its breadth little less than combined length of first two tergites, the longitudinal rugæ very strong and distinct, second tergite with about twelve on each side of middle; ovipositor (according to Enderlein) concealed.

ODONTOFORNICA PENANG sp. nov.

Male.—Differs from *O. arata* practically only in its somewhat thinner head with temples and cheeks flat, the antennæ, wing venation, and legs paler, with fully the apical third of the hind tibia red. The wings are not at all infumate. These apparent color differences may be due to immaturity, and more specimens may show that the head differences are mere variation.

Type locality.—Penang Island.

Type.—Catalogue No. 41547, United States National Museum. One specimen from the C. F. Baker collection.

ODONTOFORNICA TAGALOG sp. nov.

Female.—Differs from *O. arata* as follows:

Face shining and more coarsely punctate; temples seen from above slightly concave; mesoscutum opaque shagreened, rugulose punctate around margins and in positions of notauli, elsewhere unevenly and finely punctate, median carina strong but not distinctly elevated; mesopleurum rather coarsely rugulose-punctate, sternum finely and densely punctate; abdomen narrower, its breadth considerably less than combined length of first two tergites; longitudinal rugæ weaker and more or less confused; ovipositor fully as long as abdomen and, if in normal position, would apparently extend a short distance beyond tip of abdomen.

Black; maxillary palpi pale beyond second joint; flagellum brownish basally; wings deeply brownish infumate in apical third, venation dark; legs black, front and middle tibiæ and hind tarsi and apical half of front femur red; basal third of hind tibia white, its apex reddish; all calcaria white; hypopygium black.

Type locality.—Los Baños, Luzon, Philippine Islands.

Type.—Catalogue No. 41548, United States National Museum. One specimen from the C. F. Baker collection.

ODONTOFORNICA BORNEANUS sp. nov.

This and the following two species differ from the foregoing three species in that the scutellum has a single broad apical tooth instead of two small teeth, and in that the postscutellum lacks the tooth found in the other species.

Female.—Face shining, distinctly but finely punctate; vertex and temples polished, very obscurely punctate, cheeks more distinctly and densely punctate, vertex medially impressed and highly polished, temples from above straight, cheeks from in front convex; pronotum medially flattened and punctate, not triangularly produced on each side of middle; mesoscutum rugulose-punctate around margins and in positions of notauli, elsewhere subpolished and sparsely and weakly punctate, median carina strong; scutellum apically unidentate, postscutellum edentate; mesopleurum coarsely rugulose-punctate, sternum polished and sparsely and finely punctate; abdomen broadly ovate, its breadth nearly as great as combined length of first two tergites, the longitudinal rugæ less strong and more confused than in *O. arata*, second tergite with about twelve on each side of middle; ovipositor barely half as long as abdomen.

Black; maxillary and labial palpi pale, basal joint black; wings faintly infumate apically; hypopygium pale brown; color of legs as in *O. tagalog.*

Type locality.—Sandakan, Borneo.

Type.—Catalogue No. 41549, United States National Museum. One female from the C. F. Baker collection.

ODONTOFORNICA ANNULIPES (Ashmead) comb. nov.

Fornicia annulipes ASHMEAD, Can. Ent. 37 (1905) 7.

In addition to the unique type male there are in the United States National Museum one of each sex labelled "Philippine Islands, C. R. Jones, collector," and one female from northwestern Panay and a male from Los Baños, Luzon, both of the latter from the Baker collection.

Female.—Agrees with *O. borneanus* Cushman in the apically unidentate scutellum and edentate postscutellum, but differs from the above description of that species as follows: Temples convex; pronotum medially impressed and punctate, briefly triangularly produced each side of middle; mesoscutum medially and between notauli and marginal sculpture more shining weakly shagreened, sculpture of notauli and around margins coarser, median carina very strong, about as high as thick; mesopleurum coarsely rugose-punctate above, the sculpture becoming gradually weaker toward the polished and finely punctate sternum; abdomen distinctly narrower, the longitudinal rugæ weaker and much confused; middle tibia blackish in the middle.

Male.—Like female.

ODONTOFORNICA MORONIS sp. nov.

Female.—Similar to *O. annulipes* (Ashmead) in the medially impressed and triangularly produced pronotum, unidentate scutellum, and edentate postscutellum; but the protuberant angles of the pronotum longer; mesoscutum less shining and deeply impressed on each side of the median carina, which is much higher than thick; ovipositor nearly as long as the abdomen; hypopygium blackish; middle tibia entirely red.

Male.—Essentially like female.

Type locality.—Dapitan, Mindanao, Philippine Islands.

Type.—Catalogue No. 41551, United States National Museum. One of each sex from the C. F. Baker collection.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), V[1]

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

ONE PLATE

The present report on the crane flies of the Philippines is based on large and important collections that were made by Messrs. R. C. McGregor, Francisco Rivera, and A. C. Duyag, chiefly near Majayjay, on Mount Banahao, Luzon, and by the two latter collectors in Romblon Province. I wish to express my deepest thanks to these gentlemen for their continued interest in making known the very rich tipulid fauna of the Philippines, and for their kindness in allowing me to retain the types of the species herein defined as new.

A critical study of the so-called genera and subgenera that center about *Limonia* Meigen has been made in recent years, and it has become more and more evident that the groups constituting the subtribe Limoniaria are so plastic and grade so insensibly into one another that it is best to recognize the single genus *Limonia*. In this report I wish to discuss the limits of this large and involved genus; to list the characters available for the definition of each of the nineteen included subgenera, as here recognized; to give a key for the separation of these subgenera; and to replace with new names certain of the names that have been invalidated by this consolidation.

THE GENUS LIMONIA MEIGEN

The genus *Limonia* was proposed by Meigen in 1803. Since that date, aberrant and apparently isolated types of crane flies have been added in the vicinity of *Limonia*, most of these having been based primarily on the conformation of the wings and their venation, but a few more especially on the structure of the antennæ and mouth parts. In their typical forms, these various groups have long appeared to be quite valid, but as the fauna of

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

the World has become better known it has been found that all of them, in some region or another, pass insensibly toward and overlap others, and, in almost all cases, revert to the typical form of *Limonia.* It has become increasingly difficult correctly to assign these various nontypical forms, and the only course that remains seems to be to consider the various members of the Limoniaria as subgenera under *Limonia.* By such a procedure, any species that are in question will be correctly placed as to genus and any error in the assignment will affect the subgenus only.

The tendencies in the genus *Limonia* in the broadest sense are as follows: Antennæ 14-segmented, very rarely elongated (and then only in the male sex), sometimes pectinate (*Rhipidia* and some species of *Zelandoglochina*). Mouth parts short, with 4-segmented maxillary palpi; greatly elongated in some *Geranomyia* and *Zelandoglochina;* maxillary palpi tending to reduce in number and size of segments. A complete holopticism in a few species. Claws usually pectinate, or at least with a single basal tooth. No tibial spurs. Wings with Sc and R varying in length and relative position in different subgenera and species. The position of the free tip of Sc_2 and its outward shifting has been discussed in detail.[2] Cell M_1 always lacking; condition of cell 2d M_2 and M_3 varying in different subgenera and species; m-cu varying greatly in its relative position to the fork of M; Cu_2 sometimes entirely lacking; vein 2d A present, except in *Doaneomyia.*

The following names are regarded as synonyms: *Aporosa* Macquart, 1838, equals *Geranomyia; Ataracta* Loew, 1850, equals *Limonia; Atypophthalmus* Brunetti, 1911, equals *Limonia; Ceratostephanus* Brunetti, equals *Rhipidia; Glochina* Meigen, 1830, equals *Dicranomyia; Limnobia* Meigen, 1818, equals *Limonia; Limnobiorrhynchus* Westwood, male, 1835, equals *Geranomyia; Limnomyza* Rondani, 1856, equals *Limonia; Plettusa* Philippi, 1865, equals *Geranomyia; Siagona* Meigen, 1830, equals *Dicranomyia.* In addition, the following names, proposed as subgenera, are dropped, as being of less than subgeneric value: In *Geranomyia* (*Triphana* Skuse, *Tetraphana* Skuse, *Monophana* Edwards, *Pseudaporosa* Alexander); in *Rhipidia* (*Monorhipidia* Alexander, *Arhipidia* Alexander, *Conorhipidia* Alexander). The

[2] Alexander, Proc. Linn. Soc. New South Wales 52 (1927) 64–68, figs. 69–78.

The subgenera of *Limonia* are as follows:

Subgenus.	Date.	Genotype.	Region of typical form.
Limonia Meigen	1803	*tripunctata* Fabricius	Holarctic, Ethiopian.
Rhipidia Meigen	1818	*maculata* Meigen	Cosmopolitan, except Ethiopian.
Dicranomyia Stephens	1829	*modesta* Meigen	Cosmopolitan.
Geranomyia Haliday	1833	*unicolor* Haliday	Cosmopolitan, except New Zealand.
Discobola Osten Sacken	1865	*argus* Say	Holarctic, Australasian.
Peripheroptera Schiner	1866	*nitens* Schiner	Neotropical.
Libnotes Westwood	1876	*thwaitesiana* Westwood	Oriental, Australasian.
Dapanoptera Westwood	1881	*perdecora* Walker	Australasian.
Thrypticomyia Skuse	1889	*aureipennis* Skuse	Australasian, Oriental, Ethiopian.
Goniodineura van der Wulp	1895	*nigriceps* van der Wulp	Oriental.
Zalusa Enderlein	1906	*falklandica* Enderlein	Neotropical.
Doaneomyia Alexander	1921	*tahitiensis* Alexander	Australasian.
Euglochina Alexander	1921	*cuneiformis* de Meijere	Oriental Ethiopian.
Idioglochina Alexander	1921	*tusitala* Alexander	Australasian, Oriental.
Pseudoglochina Alexander	1921	*pulchripes* Alexander	Do.
Alexandriaria Garrett	1922	*suffusca* Garrett	Nearctic, Oriental, Australasian.
Zelandoglochina Alexander	1924	*huttoni* Edwards	Neotropical, New Zealand or Maorian.
Laosa Edwards	1926	*gloriosa* Edwards	Oriental.
Neolimnobia Alexander	1927	*diva* Schiner	Neotropical.

above names may perhaps be retained to indicate well-marked groups within their respective subgenera.

The following characters and tendencies of the various subgenera may be indicated:

Limonia MEIGEN, Illiger's Magaz. 2 (1803) 262.

Wings of normal form. Sc long, extending to beyond the origin of Rs but not beyond the end of this vein; free tip of Sc_2 opposite or beyond R_2; m-cu at or before the fork of M, rarely beyond; Cu_2 present.

Rhipidia MEIGEN, Syst. Beschr. 1 (1818) 153.

Essentially a weak modification of *Limonia,* based on the pectinate condition of the antennæ in the male sex. The group grades insensibly into *Limonia* and *Dicranomyia.*

Dicranomyia STEPHENS, Cat. Brit. Insects 2 (1829) 243.

Wings of normal form. Sc short, Sc_1 ending opposite or before the origin of Rs; free tip of Sc_2 usually opposite R_2; m-cu at or before the fork of M; Cu_2 present. Grades perfectly into *Limonia.*

Geranomyia HALIDAY, Ent. Mag. 1 (1833) 154.

Essentially a modification of *Limonia*, based on the produced mouth parts, and especially the very long labial palpi, of both sexes. A reduction in the number of segments of the maxillary palpi from four to one, this being paralleled in other subgeneric divisions. Venation and wing form as in *Limonia* and *Dicranomyia*. The group grades perfectly into *Limonia* and *Dicranomyia*, through *Pseudaporosa* and others, especially in the Australasian and Neotropical Regions.

Discobola OSTEN SACKEN, Proc. Ent. Soc. Philadelphia 1 (1865) 226.

Essentially a *Limonia* with a supernumerary crossvein in cell 1st A.

Peripheroptera SCHINER, Verh. Zool.-bot. Ges. Wien 16 (1866) 933.

Essentially a *Dicranomyia*, characterized by the unusual development of the prearcular cells of the wing, especially in the male. Wings cuneiformly narrowed at base, the apex obtusely rounded; vein Cu_2 partly atrophied, persistent basally, usually becoming obsolete opposite or before midlength of the basal section of Cu_1. Grades perfectly into *Dicranomyia*, especially in the female sex.

Libnotes WESTWOOD, Trans. Ent. Soc. London (1876) 505.

Essentially a *Limonia*, in its typical form characterized by a short, oblique Rs, long Sc, a peculiar caudad deflection of the tips of veins R_3 to M_4, and the great elongation of cell 2d M_2. Wing of typical form, long and very narrow. Very numerous species have been discovered that grade perfectly into *Limonia*. The most satisfactory characters still remaining for separating these two groups are those outlined by Edwards (1928); namely, long Sc, Sc_1 usually ending beyond the fork of Rs; usually oblique Rs; position of m-cu beneath cell 1st M_2, sometimes as far distad as its outer end, in rare cases at the fork of M. The group grades insensibly into *Limonia*.

Dapanoptera WESTWOOD, Trans. Ent. Soc. London (1881) 365.

Essentially a *Limonia*, distinguished by a supernumerary crossvein in cell R_5.

Thrypticomyia SKUSE, Proc. Linn. Soc. New South Wales, II 4 (1889) 774.

A modification of the type of *Dicranomyia*. Wings strongly cuneiformly narrowed; Sc short; free tip of Sc_2 before R_2; R_{1+2} with a strong terminal spur; fork of Rs at near three-fourths the wing length; Cu_2 entirely atrophied; vein 2d A present.

Goniodineura VAN DER WULP, Tijdschr. v. Ent. 38 (1895) 37.

A weak modification of *Libnotes*, represented by a single widespread Malayan species, characterized especially by the strong subbasal angulation of both Rs and R_{2+3}.

Zalusa ENDERLEIN, Zool. Anzeig. 29 (1906) 70–71.

A degenerate modification of *Limonia*, characterized essentially by the subapterous condition of both sexes.

Doaneomyia ALEXANDER, Bull. Brooklyn Ent. Soc. 16 (1921) 11.

Characterized by the total loss of vein 2d A. Wings long-petiolate basally.

Euglochina ALEXANDER, Can. Ent. 53 (1921) 207–208.

A modification of *Dicranomyia*, characterized by the extreme distal position of the cord which lies at or beyond four-fifths of the length of the wing. Wings cuneiformly narrowed; Sc unusually short, ending approximately opposite the tip of vein 2d A; Rs short to very short; Cu_2 atrophied wholly or in part, in the latter case ending before midlength of the basal section of Cu_1.

Idioglochina ALEXANDER, Can. Ent. 53 (1921) 207.

A weak modification of *Dicranomyia*, distinguished especially by peculiar modifications of the antennæ of the male sex, the ventral face of the flagellar segments being greatly produced and provided on the periphery with stout spinous setæ. Some species have been confused with *Rhipidia*, but the nature of the antennal modification is quite distinct in the two groups. The male sex shows a notable incrassation of costa and peculiar arcuations of certain of the veins of the radial field.

Pseudoglochina ALEXANDER, Can. Ent. 53 (1921) 208.

A modification of *Limonia*. Wings strongly narrowed and petiolate at base; elements of anterior cord in oblique alignment, like *Libnotes;* Sc_1 extending some distance beyond base of Rs; cell M_2 open by the atrophy of the basal section of M_3; m-cu at or close to the fork of M; Cu_2 persistent almost to the level of m-cu. Edwards[3] has shown the affinities of this group to *Doaneomyia* and indicated the probable manner in which the second anal vein of the latter group has been lost. It should be further noted that *Doaneomyia* has lost vein Cu_2, whereas *Pseudoglochina* has it long and persistent.

[3] Insects of Samoa, Nematocera (1928) 78–79.

Alexandriaria GARRETT, Proc. Ent. Soc. Washington 24 (1922) 60.

A weak modification of *Dicranomyia*. The essential features of the venation lie in the total loss of cell M_3 by the complete atrophy of m and both sections of M_3. As has been pointed out by Edwards, this is essentially a group of convenience, since the same tendency has been found in several groups of the genus. It is of interest to note that a *Euglochina*, described as new at this time, has this same peculiar venation.

Zelandoglochina ALEXANDER, Ann. and Mag. Nat. Hist. IX 13 (1924) 449–500.

Essentially a *Geranomyia* but with the frontal prolongation of the head short, the maxillary palpi at its apex and thus appearing to lie close to base of rostum. The great elongation of the latter is made up of labial palpi. Antennæ of male strongly nodulose, in one species flabellate as in *Rhipidia*. In the Maorian and Chilian subregions, the group grades insensibly into *Dicranomyia* by a reduction of the mouth parts.

Laosa EDWARDS, Encylop. Entomol. ser. B., Diptera 3 (1926) 48.

A modification of *Limonia*, distinguished especially by the reduction in length to total obliteration of r-m by the approximation of the adjoining veins, together with the presence of supernumerary crossveins in cells R_3 and R_5. Too much importance should not be placed on the latter character, since it is likewise found in certain species of *Libnotes* (as *regalis* Edwards) for which no generic or subgeneric group is deemed necessary.

Neolimnobia ALEXANDER, Proc. Linn. Soc. New South Wales 52 (1927) 68.

Essentially a *Dicranomyia* with a supernumerary crossvein in cell R_3.

A key to the subgenera of the genus Limonia Meigen.

1. A single anal vein present.................................... *Doaneomyia* Alexander.
   Two anal veins present.. 2.
2. Both sections of vein M_3 and m lacking, cell M_3 thus always lacking.. 3.
   At least the distal section of vein M_3 present and usually both sections, together with m, cell M_3 thus usually present.................................... 4.
3. Cord of wing lying far distad, at or beyond four-fifths the wing length.
   Euglochina Alexander, in part (*projecta*, sp. nov.).
   Cord of wings normal, not lying beyond two-thirds to three-fourths the length of the wing.. *Alexandriaria* Garrett.
4. Wings reduced to mere stubs in both sexes................ *Zalusa* Enderlein.
   Wings fully developed in both sexes.. 5.

5. Supernumerary crossveins present in one or more cells of the wing.. 6.
No supernumerary crossveins in cells of wing (except a weak element sometimes evident in subcostal cell) .... 11.
6. A supernumerary crossvein in cell 1st A........ *Discobola* Osten Sacken.
No crossvein in cell 1st A.......... 7.
7. Supernumerary crossveins in a single radial cell.......... 8.
Supernumerary crossveins in two radial cells.......... 10.
8. A supernumerary crossvein in cell R_3.......... 9.
A supernumerary crossvein in cell R_5 .... *Dapanoptera* Westwood.
9. Sc short, Sc_1 ending opposite or before the origin of Rs; supernumerary crossvein lying distad of the tip of vein R or outer end of cell 1st M_2; m-cu at fork of M.......... *Neolimnobia* Alexander.
Sc long, Sc_1 ending beyond the fork of Rs; supernumerary crossvein lying proximad of R_2 and outer end of cell 1st M_2; m-cu beyond fork of M.......... *Libnotes* Westwood. in part (*fuscinervis* Brunetti, *transversalis* de Meijere).
10. r-m greatly reduced or entirely obliterated by the fusion of Rs on M_{1+2}.......... *Laosa* Edwards.
r-m of normal length.... *Libnotes* Westwood, in part (*regalis* Edwards).
11. Mouth parts, and especially the labial palpi, lengthened, longer than the head, usually much longer.......... 12.
Mouth parts, with the labial palpi, not notably lengthened, shorter than the head .... 13.
12. Antennæ strongly nodulose, rarely flabellate; frontal prolongation of head short, the maxillary palpi not far from base of rostrum. *Zelandoglochina* Alexander.
Antennæ not nodulose; frontal prolongation long, forming a considerable portion of the base of rostrum, the maxillary palpi at its tip and thus appearing remote from base of rostrum. *Geranomyia* Haliday.
13. Antennæ of male more or less branched (bipectinate, unipectinate, or subpectinate) or with the lower face of the flagellar segments produced to give the organ a serrate appearance.......... 14.
Antennæ simple in both sexes.......... 15.
14. Antennæ more or less distinctly branched; bipectinate (*Rhipidia*, s. s.), unipectinate (*Monorhipidia*), or subpectinate (*Archipidia*). *Rhipidia* Meigen.
Antennæ with the ventral face of each flagellar segment produced into a flattened lobe, its periphery set with stout spinous setæ. *Idioglochina* Alexander.
15. Cord of wings lying far distad, at or beyond four-fifths the length of the wing .... *Euglochina* Alexander.
Cord of wings normal in position, lying more proximad, at or near two-thirds and not exceeding three-fourths the length of wing.... 16.
16. Cu_2 entirely lacking..........*Thrypticomyia* Skuse.
Cu_2 present, in most cases extending to opposite m-cu, at least extending to midlength of the basal section of Cu_1 .... 17.
17. Wings of male with the prearcular region greatly developed; wing tip very obtuse.......... *Peripheroptera* Schiner.
Wings in both sexes with small, normal prearcular cells; wing tip not conspicuously obtuse.......... 18.

18. Both Rs and R $_{2+3}$ angularly bent near origin.
Goniodineura van der Wulp.
Rs sometimes angulated but not coincidentally with any angulation of R $_{2+3}$ .... 19.
19. Sc relatively short, ending opposite or before origin of Rs.
Dicranomyia Stephens.
Sc ending some distance beyond the origin of Rs........ 20.
20. Wings strongly cuneiformly narrowed at base; Rs and anterior cord in oblique alignment; cell M_2 open by atrophy of basal section M_3.
Pseudoglochina Alexander.
Wings not with the above combination of characters; when Rs and anterior cord are in oblique alignment, cell 1st M_2 closed........ 21.
21. Rs short and oblique, Sc extending to beyond its fork; radial veins deflected strongly caudad at outer ends; m-cu beneath cell 1st M_2.
Libnotes Westwood, in part.
Rs longer and more arcuated, Sc not extending to opposite its fork; veins beyond the cord, including the radial veins, not deflected strongly caudad at tips; m-cu at, before, or only slightly beyond the fork of M .... *Limonia* Meigen.

As a result of the uniting of the above names in the single genus *Limonia*, a number of specific names become homonyms. A certain number of these are renamed herewith, these including only species described by deceased or inactive workers. A considerable number of additional preoccupied names of species described by contemporary and active workers likewise exist and it is advisable that they be renamed as soon as practicable.

Limonia (*Limonia*) *brunettiella* nom. nov., for *L.* (*L.*) *confinis* Brunetti, Rec. Indian Mus. **15** (1918) 290, nec *L.* (*Dicranomyia*) *confinis* Bergroth, Wien. Ent. Zeitung **8** (1889) 116.

Limonia (*Limonia*) *marginella* nom. nov., for *L.* (*L.*) *marginata* Brunetti, Rec. Indian Mus. **15** (1918) 290, nec *L.* (*Dicranomyia*) *marginata* Macquart, Recueil Soc. Sc. Agr. Lille (1826) 151.

Limonia (*Limonia*) *nigricans* nom. nov., for *L.* (*L.*) *nigrescens* Brunetti, Rec. Indian Mus. **15** (1918) 293, nec *L.* (*Dicranomyia*) *nigrescens* Hutton, Trans. New Zealand Inst. **32** (1900) 34.

Limonia (*Limonia*) *nigrella* nom. nov., for *L.* (*L.*) *nigronitida* Alexander, Ann. Ent. Soc. America **16** (1923) 60–61, nec *L.* (*Geranomyia*) *nigronitida* Alexander, Can. Ent. **53** (1921) 208–209.

Limonia (*Rhipidia*) *willistoniana* nom. nov., for *L.* (*R.*) *costalis* Williston, Trans. Ent. Soc. London (1896) 286, nec *L.* (*Limonia*) *costalis* Wiedemann, Analecta Entomologica (1824) 10.

Limonia (*Rhipidia*) *punctoria* nom. nov., for *L.* (*R.*) *punctipennis* Alexander, Journ. New York Ent. Soc. **22** (1914) 117, nec *L.* (*Dicranomyia*) *punctipennis* Skuse, Proc. Linn. Soc. New South Wales II **4** (1889) 761.

Limonia (*Rhipidia*) *luxuriosa* nom. nov., for *L.* (*R.*) *vicina* Alexander, Trans. Am. Ent. Soc. 42 (1916) 8–9, nec *L.* (*Geranomyia*) *vicina* Macquart, Hist. Nat. d'Îles Canaries, Ent., Dipt. (1838) 101.

Limonia (*Dicranomyia*) *cramptoniana* nom. nov., for *L.* (*D.*) *cramptonia* Alexander, Ent. News 39 (1926) 47–49, nec *L.* (*Rhipidia*) *cramptoni* Alexander, Bull. Brooklyn Ent. Soc. 8 (1912) 10–11.

Limonia (*Dicranomyia*) *divisa* nom. nov., for *L.* (*D.*) *diversa* Osten Sacken, Proc. Acad. Nat. Sci. Philadelphia (1859) 212, nec *L.* (*Geranomyia*) *diversa* Osten Sacken, Ibid. (1859) 207.

Limonia (*Dicranomyia*) *brevivenula* nom. nov., for *L.* (*D.*) *flavescens* Dietz, Trans. Am. Ent. Soc. 47 (1921) 239, nec *L.* (*Limonia*) *flavescens* Macquart, Suit. a Buffon, Dipt. 1 (1834) 103.

Limonia (*Dicranomyia*) *primæva* nom. nov., for *L.* (*D.*) *primitiva* Alexander, Ann. and Mag. Nat. Hist. IX 13 (1924) 562–563, nec *L.* (*D.*) *primitiva* Scudder, Tertiary Insects (1890) 570.

Limonia (*Dicranomyia*) *rostralis* nom. nov., for *L.* (*D.*) *rostrata* Scudder, Tertiary Insects (1890) 571, nec *L.* (*Geranomyia*) *rostrata* Say, Journ. Acad. Nat. Sci. Philadelphia 3 (1823) 22.

Limonia (*Dicranomyia*) *scudderiana* nom. nov., for *L.* (*D.*) *simplex* Scudder, Tertiary Insects (1890) 573, nec *L.* (*Libnotes*) *simplex* Osten Sacken, Ann. Mus. Civ. Genova 16 (1881) 202, and others.

Limonia (*Geranomyia*) *annulosa* nom. nov., for *L.* (*G.*) *annulata* Skuse, Proc. Linn. Soc. New South Wales II 4 (1889) 780, nec *L.* (*Discobola*) *annulata* Linnæus, Syst. Nat. ed. 10 (1758) 586.

Limonia (*Geranomyia*) *skuseana* nom. nov., for *L.* (*G.*) *fusca* Skuse, Proc. Linn. Soc. New South Wales II 4 (1889) 780, nec *L.* (*Dicranomyia*) *fusca* Meigen, Klass 1 (1804) 54, and others.

Limonia (*Geranomyia*) *pallidula* nom. nov., for *L.* (*G.*) *pallida* Williston, Trans. Ent. Soc. London (1896) 284, nec *L.* (*Dicranomyia*) *pallida* Macquart, Dipt. exot. 1 (1838) 72.

Limonia (*Geranomyia*) *austropicta* nom. nov., for *L.* (*G.*) *picta* Skuse, Proc. Linn. Soc. New South Wales II 4 (1889) 778, nec *L.* (*Limonia*) *picta* Heer, Insectenfauna von Oeningen und Radaboj in Croatien 2 (1849) 197.

Limonia (*Geranomyia*) *devota* nom. nov., for *L.* (*G.*) *pulchella* Alexander, Trans. Am. Ent. Soc. 40 (1914) 228–229, nec *L. pulchella* Meigen, Syst. Beschr. 6 (1830) 275.

Limonia (*Geranomyia*) *pictorum* nom. nov., for *L.* (*G.*) *pulchripennis* Brunetti, Fauna British India, Diptera Nematocera (1912) 393, nec *L.* (*Dicranomyia*) *pulchripennis* Brunetti, Ibid. (1912) 376.

Limonia (*Geranomyia*) *tristella* nom. nov., for *L.* (*G.*) *tristis* Loew, Linnaea Entomologica 5 (1851) 398, nec *L.* (*Dicranomyia*) *tristis* Schummel, Beitr. zur Entomol. 1 (1829) 135.

Limonia (*Discobola*) *pictoralis* nom. nov., for *L.* (*Discobola*) *picta* Hutton, Trans. New Zealand Inst. 32 (1900) 37, nec *L.* (*Geranomyia*) *picta* Skuse, Proc. Linn. Soc. New South Wales II 4 (1889) 778.

Limonia (*Discobola*) *venustula* nom. nov., for *L.* (*Discobola*) *venusta* Osten Sacken, Berliner Ent. Zeitschr. 39 (1894) 265, nec *L.* (*Limonia*) *venusta* Bergroth, Wien. Ent. Zeitg. 7 (1888) 193.

Limonia (*Peripheroptera*) *austroandina* nom. nov., for *L.* (*P.*) *subandina* Alexander, Journ. New York Ent. Soc. 27 (1919) 135–136, nec *L.* (*Dicranomyia*) *subandina* Alexander, Proc. U. S. Nat. Mus. 44 (1913) 488.

Limonia (*Libnotes*) *sackenina* nom. nov., for *L.* (*L.*) *simplex* Osten Sacken, Ann. Mus. Civ. Genova 16 (1881) 202, nec *L. simplex* Wiedemann, Aussereur. zweifl. Ins. 1 (1828) 549; nec *L. simplex* Meigen, Syst. Beschr. 6 (1830) 277.

Limonia (*Thrypticomyia*) *unisetosa* nom. nov., for *L.* (*T.*) *arcuata* Alexander, Trans. Am. Ent. Soc. 46 (1920) 4, nec *L.* (*Peripheroptera*) *arcuata* Alexander, Ent. News 24 (1913) 411–412.

TIPULINÆ

PSELLIOPHORA NIGRORUM sp. nov.

Thorax entirely black; anterior vertex abruptly yellow; palpi yellow; fore and middle femora black, the bases narrowly yellow; posterior femora yellow, the tips blackened; all tibiæ black, with a subbasal white ring; wings dark brown, the base broadly yellow; a paler yellow V-shaped area on the disk; abdomen with the basal segments reddish orange, the apex, including the hypopygium, black.

Male.—Length, about 14 millimeters; wing, 14.2.

Frontal prolongation of head very high and tumid, at base fully as deep as the vertex, thus gradually sloping from the vertex to its anterior end, obscure yellow above, dark brown laterally; palpi pale yellow, the distal end of the last segment a little darkened. Antennæ with the scape and basal segment of flagellum yellow; succeeding flagellar segments obscure yellow, the branches black, the apices of the segments narrowly pale; outer flagellar segments uniformly darkened. Head black, the anterior vertex abruptly yellow, the posterior margin of this area evenly rounded.

Prothorax, mesonotum, and pleura entirely deep velvety black. Halteres with the basal half of the stem yellow, the remainder dark brown. Legs with the coxæ black; trochanters reddish yellow; fore and middle femora black, with about the basal

fourth yellow; posterior femora yellow with a little more than the distal third black; all tibiæ black, with a narrow subbasal white ring; tarsi black. Wings dark brown, the base broadly and conspicuously bright yellow, this including the entire prearcular region and bases of the cells beyond, with the basal third of cell 2d A of this color; a conspicuous V-shaped mark on disk that is of a somewhat paler yellow than the base; pale streaks along vein 1st A and near central portion of this cell.

Basal four abdominal segments reddish orange, the remainder, including the hypopygium, black; basal sternites black medially, broadly reddish laterally, the amount of black increasing on the outer segments. Male hypopygium with the lateral lobes of the tergite densely tufted with setæ. Eighth sternite carinate medially, the prow-shaped apex chiefly reddish fulvous.

NEGROS, northern Oriental Negros, Lake Dako, July, 1925; holotype, male.

By Edwards's key to the Philippine species of *Pselliophora,*[4] *P. nigrorum* runs to couplet 7, agreeing with *P. tigriventris* Alexander in the broad yellow wing bases but differing conspicuously in the entirely black thorax and the coloration of the abdomen, which has about the basal half uniformly red, the apex entirely black.

SCAMBONEURA PRIMÆVA sp. nov. Plate 1, figs. 1 and 2.

General coloration obscure fulvous yellow, the præscutum with four shiny plumbeous stripes that are narrowly bordered by black; antennal flagellum black; wings relatively broad, tinged with gray; Rs and the anterior cord in approximate transverse alignment, the latter not arcuated; cells of the medial field of wing relatively wide; abdominal tergites obscure yellow, the subcaudal portions shiny plumbeous, the caudal margins narrowly dark brown.

Female.—Length, about 15 millimeters; wing, 13.

Frontal prolongation of head deep fulvous, with a narrow dorsomedian black vitta that includes the conspicuous nasus; palpi dark brown, the two intermediate segments somewhat paler. Antennæ with the scapal segments obscure yellow; first flagellar segment dark brown; remainder of organ black. Head fulvous yellow, the anterior vertex narrowly lined with black.

Pronotum brown, more yellowish dorsomedially. Mesonotal præscutum obscure fulvous yellow with four shiny plumbeous

[4] Notulae Entomologicae 6 (1926) 41.

stripes that are narrowly margined with black; scutal lobes similarly darkened; scutellum dark, more brownish yellow laterally, the parascutella yellow; postnotum dark brown. Pleura obscure fulvous yellow, the meron darker; posterior sclerites, including the pleurotergite, more testaceous yellow. Halteres brown, the knobs darker, the base of the stem restrictedly pale. Legs with the coxæ reddish brown; trochanters pale brown; femora yellowish brown, brighter basally; tibiæ dark brown, the tips narrowly blackened; tarsi passing into black. Wings (fig. 1) relatively broad, tinged with gray; cell Sc darker; stigma small, pale brown; veins dark brown. Venation: Rs very short, in approximate alignment with the remainder of the anterior cord, the latter not strongly bowed, as in the other known species of the genus; R_2 lost by fusion of R_1 with R_{2+3}; distal section of R_{1+2} atrophied; forks of medial field relatively short and broad; m-cu very erect, its angle with Cu_1 obtuse.

Abdominal tergites obscure yellow, the subcaudal portions of the intermediate segments more plumbeous and highly polished; caudal margins of the segments narrowly dark brown; sternites more uniformly brownish yellow. Ovipositor with the genital shield shiny castaneous; tergal valves of ovipositor yellowish horn color.

LUZON, Mountain Province, Benguet, Pauai (Haight's place), altitude about 2,400 meters, May 1926; holotype, female.

Scamboneura primæva is very distinct from the other Philippine species of the genus. By the author's key to the species of *Scamboneura*,[5] the present form would run to *S. faceta* Alexander, a very different fly. The generalized condition of the venation of the radial field of the wing is noteworthy and finally settles the argument that the small transverse element at the proximal end of the stigma, first interpreted as being Rs, really is this vein. The strongly bowed condition of the anterior cord in the other known species of the genus, with a small spur jutting basad into cell R, lead to the possibility of an alternative interpretation,[6] but the primitive condition of the venation in the present species proves that the original explanation of this remarkable venation is the correct one. The venation of *S. psarophanes* Alexander is shown for comparison (fig. 2).

[5] Philip. Journ. Sci. 33 (1927) 293.

[6] Alexander, Proc. Linn. Soc. New South Wales 52 (1927) 60, fig. 54.

Genus MACGREGOROMYIA novum

Frontal prolongation of head relatively stout, the nasus unusually long and slender. Antennæ apparently only 12-segmented, the basal segment elongate. No vertical tubercle. Legs long and slender; tibial spurs small; claws (♀) simple. Wings (fig. 3) with Sc_1 completely preserved, Sc_2 short, at its tip; Rs strongly arcuated; r-m connecting with Rs at nearly its own length before the fork; R_{2+3} gently arcuated on basal half; free tip of Sc_2 and R_{1+2} entirely preserved, converging outwardly, cell Sc_2 broadest at proximal end; R_3 long, cell R_2 at margin very wide; cell 1st M_2 present; all medial cells relatively deep; m-cu just beyond the fork of M; vein 2d A nearly straight. Ovipositor with the valves chitinized, the tergal valves nearly straight and relatively slender; sternal valves very short and high, nearly as wide as long.

Genotype, *Macgregoromyia benguetensis* sp. nov. (Oriental Region.)

I take great pleasure in naming this new group in honor of my friend and colleague, Mr. Richard C. McGregor, to whom I am very greatly indebted for aid in a study of the rich crane-fly fauna of the Philippines and for other kind favors. I cannot refer the present fly to any of the described groups of tipuline crane flies. The position of r-m on Rs before the fork of the latter provides a unique character for the definition of the present group. Other striking characters and combinations of characters lie in the retention of Sc_1, the preservation of R_{1+2} and its close approximation at wing margin to the free tip of Sc_2, the long, parallel-sided cell 1st M_2, and the position of m-cu.

MACGREGOROMYIA BENGUETENSIS sp. nov. Plate 1, fig. 3.

General coloration fulvous brown, the mesonotum chiefly dark brown; base of antennæ yellow, the outer segments dark brown; pleura pale, variegated with dark brown; legs relatively long and slender; femora obscure yellow at base, more darkened outwardly, the tips again paler; wings pale yellow, longitudinally striped with brown; abdominal tergites dark brown, the caudal margins of the segments broadly brownish yellow.

Female.—Length, about 14 millimeters; wing, 13.8.

Frontal prolongation of head brownish yellow, darker laterally; nasus long, slightly widened distally, a little brighter than the front; palpi pale brown, the third segment brighter, the

terminal segment broken. Antennæ with the first segment yellow, the second segment almost white; basal two flagellar segments yellow, the succeeding segments passing into brown. Head dark fulvous brown; anterior vertex wide.

Pronotum chiefly brownish yellow. Mesonotal præscutum with the disk largely covered by confluent brown stripes, the broad lateral margins abruptly yellow; margins of lateral stripes and anterior interspaces a little darker than the stripes; scutal lobes darkened, the median area slightly paler; scutellum dark brown; postnotum dark brown, laterally with dense yellow pollen. Pleura pale, the anepisternum and sternopleurite variegated with dark brown. Halteres relatively long and slender, pale, the base of the knobs dark brown, the apex paler. Legs with the coxæ dark brown; trochanters obscure yellow; femora obscure yellow, darkened outwardly, the tips paling into yellow; bases of tibiæ narrowly yellowish, the remainder of the legs passing into dark brown. Wings (fig. 3) with the ground color pale yellow, the veins conspicuously bordered with brown to produce a vittate appearance; cell C brownish yellow, pale yellow at outer end; cell Sc more uniformly yellow; cord conspicuously seamed with brown; radial cells more uniformly infumed, the proximal two-fifths of cell R_3 pale yellow; cells beyond cord infumed, a large area centering about cell 1st M_2, together with all of cell M_1 pale; bases of cells R and M, basal two-thirds of Cu, vein 2d A and axilla all conspicuously variegated with brown. Venation as discussed under the generic diagnosis.

Abdominal tergites dark brown, the caudal margins of the segments broadly brownish yellow; sternites more uniformly brownish yellow. Ovipositor with the tergal valves brownish horn color.

LUZON, Mountain Province, Benguet, Pauai (Haight's place), altitude about 2,400 meters, May, 1926; holotype, female.

LIMONIINÆ

LIMONIA (LIBNOTES) IGOROTA sp nov. Plate 1, fig. 4.

Size large (wing, ♂, over 20 millimeters); general coloration yellow, the posterior sclerites of the mesonotum variegated with dark brown; antennal flagellum and terminal segments of palpi yellow; thoracic pleura yellow, narrowly lined with dark brown; halteres yellow; legs yellow, the femora only vaguely darkened subapically on outer face; wings with a strong yellow tinge, the veins with long brown streaks, on Cu and on R_{4+5} extending

almost unbroken the entire length of the vein; R_{1+2} about three times R_2 alone; inner end of cell 2d M_2 far proximad of cell M_3.

Male.—Length, about 15 millimeters; wing, 22 by 4.6.

Rostrum dark brown; palpi short, the first segment dark brown, the short outer three segments yellow. Antennæ with the scapal segments dark brown; flagellum abruptly light yellow; basal segments of flagellum with relatively short spinous verticils; outer segments more elongate. Head deep fulvous yellow, without markings; anterior vertex reduced to a strip.

Pronotum yellow. Mesonotal præscutum greenish yellow, with four nearly concolorous stripes, these becoming narrowly dark brown just before the suture; scutum with the median area greenish gray, the lobes olive-yellow with their centers dark brown; scutellum dark brown, the median area obscure yellow; postnotal mediotergite dark brown, the caudal margin narrowly yellow, the disk with a conspicuous median pale area that is narrowed behind. Pleura yellow with two narrow, slightly interrupted, dark brown, longitudinal stripes; dorsal stripe extending from the ventral margin of the pronotum, across the propleura and anepisternum, onto the pteropleurite, interrupted beyond this by the pleurotergite, which has only a small area above the halteres; ventral stripe interrupted, beginning on the fore coxa, including large areas on the sternopleurite and middle coxa, and above the hind coxa. Halteres entirely yellow. Legs with the fore and middle coxæ yellow, the outer face darkened as above described; hind coxæ yellow; trochanters obscure yellow; femora obscure yellow, with a barely indicated subterminal darkening that does not form a complete ring, the tips clear yellow; tibiæ and tarsi obscure yellow, the latter passing into black; segments, especially of the fore legs with the setæ reduced to tiny spines. Wings (fig. 4) with a strong yellow tinge, the veins conspicuously seamed with brown, the seams along Rs, R_5 and Cu nearly uninterrupted; other areas include a streak on R_{2+3} below the fork of Sc, R_2, tip of R_{1+2} a long area at outer end of M_{1+2}, outer end of cell 1st M_2 and the tips of the anal veins; a dark marginal seam from 1st A almost to the tip of vein M_4; veins yellow, darker in the infuscated areas. Venation: Sc_2 at tip of Sc_1; Rs short, oblique; R_{1+2} elongate, fully three times R_2 alone, the free tip of Sc_2 carried to its extreme outer end; proximal end of cell 2d M_2 lying far proximad of cell M_3; m-cu about two and one-half times its length beyond the fork of M.

Abdominal tergites brownish yellow, with a narrow, dark brown lateral stripe that becomes obsolete on the outer segments; hypopygium yellow.

LUZON, Mountain Province, Benguet, Baguio; holotype, male.

In its large size and general coloration of the wings, *L.* (*L.*) *igorota* resembles *L.* (*L.*) *regalis* (Edwards), of Formosa, differing conspicuously in the entire lack of supernumerary crossveins, and all details of coloration of the body, antennæ, and legs. By Edward's key to the species of *Libnotes*,[7] the present species runs to couplet 13, disagreeing with both included groups of species by the combination of striped thoracic pleura and uniformly yellow halteres. The pale yellow antennal flagellum and almost immaculate femora are conspicuous features of the present species.

LIMONIA (LIBNOTES) BANAHAOENSIS sp. nov. Plate 1, fig. 5.

General coloration brownish gray; antennæ black throughout; pleura pale yellow, with a transverse brown girdle; legs brown, the narrow tips of the femora and the bases of the tarsi paler; wings whitish subhyaline, with a heavy brown pattern, including areas in the base of cell R and at the wing tip; costal margin yellow, alternating with larger brown areas; Rs arcuated; free tip of Sc_2 before R_2; cells 2d M_2 and M_3 with their inner ends in transverse alignment.

Sex?—Wing, 6.7 millimeters.

Rostrum about one-half the length of the head, pale brown basally, the apex and palpi black. Antennæ black throughout; flagellar segments long-oval, the unilaterally arranged verticils approximately twice the segments. Posterior vertex dark, the narrow anterior vertex more grayish. Eyes large, contiguous or virtually so on dorsum.

Mesonotum almost uniformly brownish gray, the præscutum with a median darker brown stripe; scutellum more testaceous; pleurotergite yellow. Pleura pale yellow, with a brown transverse girdle, involving the cephalic portions of the anepisternum and sternopleurite, the posterior margin of the propleura, and the fore coxæ. Halteres elongate, dark brown. Legs with the fore coxæ dark, the remaining coxæ and all trochanters pale yellow; femora brown, the bases paler, the extreme tips narrowly yellow; tibiæ brown, the tips paling into brownish yellow; basal two tarsal segments yellow, the terminal segments black. Wings (fig. 5) whitish subhyaline, with a heavy brown pattern;

[7] Journ. Federated Malay States Mus. 14 (1928) 74–80.

costal margin in cells C and Sc yellow, alternating with extensive brown areas above h, over origin of Rs, tip of Sc and the small stigmal area above the end of R; wing apex in cells R_2 and R_3 broadly infumed; an extensive dark cloud in base of cell R; broad, conspicuous brown seams along Cu, the cord, outer end of cell 1st M_2, R_{2+3} R_3 and the tip of 2d A; veins dark brown, yellow in the costal interspaces. Venation: Sc_1 extending to shortly beyond the level of r-m; Rs gently arcuated, nearly three times the basal section of R_{4+5}; free tip of Sc_2 about its own length before R_2; radial veins long and extending generally parallel to one another to margin; cell 1st M_2 elongate, gently widened distally, the proximal ends of cells 2d M_2 and M_3 in transverse alignment; m-cu about its own length beyond fork of M; vein 2d A strongly converging toward 1st A on basal half, thence diverging strongly to margin.

Abdomen with the basal segments greenish yellow, a little infumed; abdomen broken beyond the third segment.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, June 10, 1928 (*R. C. McGregor*); holotype.

Limonia (*L.*) *banahaoensis* belongs to the group of the subgenus that includes small *Limonia*-like forms, with the transverse veins at outer end of cell 1st M_2 in alignment. By Edwards's key to the species of *Libnotes*,[8] the present species runs to couplet 36, disagreeing with both groups in the small stigma and clouded wing apex. The coloration of the wings readily separates this species from all forms so far described.

LIMONIA (LIBNOTES) RIVERAI sp. nov. Plate 1, fig. 6.

General coloration gray; rostrum, palpi, and antennæ black; femora brownish yellow, the tips narrowly and inconspicuously brownish black; wings grayish subhyaline, the prearcular region more whitish; stigma lacking; free tip of Sc_2 and R_2 in alignment; proximal ends of cells 2d M_2 and M_3 in alignment.

Female.—Length, about 6 to 7 millimeters; wing, 6.5.

Rostrum and palpi black, the former about one-half the length of the remainder of the head. Antennæ black throughout, the flagellar segments oval, somewhat longer outwardly, the terminal segment nearly twice the penultimate. Anterior vertex narrow, silvery white; remainder of head dark gray, the posterior orbits paler.

[8] Loc. cit.

Mesonotum dark brownish gray, the præscutum with three poorly defined darker brown stripes; posterior sclerites of mesonotum clearer gray. Pleura dark grayish brown, the dorsopleural region paler. Halteres with the stem yellow, the outer end and the knobs dark brown. Legs with the coxæ dark, concolorous with the pleura; trochanters obscure yellow; legs relatively long; femora brownish yellow, the tips narrowly brownish black; tibiæ brown, the tips narrowly darkened; tarsi brownish yellow, the terminal segments blackened. Wings (fig. 6) grayish subhyaline; prearcular region pale; cell Sc a little more infumed; stigma lacking; veins dark brown. Venation: Sc_1 ending about opposite midlength of basal section of R_{4+5}, Sc_2 close to its tip; Rs about twice the basal section of R_{4+5}, the basal half more oblique, the distal half more arcuated; free tip of Sc_2 in alignment with R_2; cell 1st M_2 relatively elongate but shorter than the veins issuing from it; inner ends of cells 2d M_2 and M_3 in alignment; m-cu at near three-fifths to two-thirds the lengh of cell 1st M_2; 2d anal vein diverging gently from 1st A, beyond the base gently sinuous, the cell broad.

Abdomen dark brown. Ovipositor with the valves reddish horn color; tergal valves slender.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, May 30, 1928 (*R. C. McGregor and Francisco Rivera*); holotype, female; paratopotype, female. "On small tree trunk in open field, far from water."

I take great pleasure in naming this interesting *Limonia* in honor of the collector of many of the specimens studied in connection with the present report, Mr. Francisco Rivera. *Limonia (L.) riverai* differs from all similar *Limonia*-like species of the subgenus *Libnotes* in the gray coloration of the thorax and the unmarked wing. By Edwards's key to the species of the subgenus,[9] the present species would run to couplet 55, disagreeing with both sets of characters in the immaculate wings.

LIMONIA (LIBNOTES) DUYAGI sp. nov. Plate 1, fig. 7.

Ground color reddish yellow, the thorax heavily variegated with brownish black, including three præscutal stripes; knobs of halteres light yellow; legs chiefly yellow, the fore femora with a narrow dark brown subterminal ring; wings subhyaline, the costal border and base more darkened; stigma small, subcircular, darker brown; Rs long; cell 2d M_2 a little longer than

[9] Loc. cit.

cell M_3; m-cu at near midlength of cell 1st M_2; anal veins nearly parallel at base.

Female.—Length, about 6.5 millimeters; wing, 6.8.

Rostrum and palpi black. Antennæ with the scape black, the flagellum much paler, light brown; flagellar segments oval, the verticils not conspicuous. Head dark brownish gray with a blackish median line; eyes broadly contiguous on the vertex.

Pronotum narrowly black medially and laterally, paler on either side of the median line; posterior notum obscure yellow. Mesonotal præscutum with the ground color reddish yellow, the three stripes black, very extensive, confluent behind or nearly so; median stripe constricted and diluted with reddish opposite the anterior ends of the lateral stripes; scutal lobes dark brown, the median area yellow; scutellum brownish black, the base obscure yellow; postnotum brown. Pleura obscure yellow, sparsely variegated with brown, the most distinct area on the anepisternum; dorso pleural region more or less darkened. Halteres pale, the base of the stem and the knobs light yellow. Legs with the coxæ and trochanters yellow, the fore coxæ darker; fore femora yellow with a narrow dark brown subterminal ring, this narrower than the yellow apex beyond; remaining femora with the subterminal dark annulus more diffuse, only the outer end clearly delimited; tibiæ yellow, the tips very narrowly and vaguely darkened; tarsi yellow, the outer three segments dark brown. Wings (fig. 7) subhyaline, the prearcular region, cells C and Sc, and a more-diffuse costal border extending to the wing tip brown; stigma subcircular, darker brown; caudal border of wing more vaguely infumed; a narrow brown seam at origin of Rs; bases of cells R, M, Cu, and 1st A a little clouded; veins dark brown. Venation: Sc_1 ending shortly beyond r-m, Sc_2 a short distance from its tip; Rs long, rather strongly arcuated, some five times the basal section of R_{4+5}; free tip of Sc_2 and R_2 in alignment; cell 2d M_2 a little longer than cell M_3; cell 1st M_2 elongate, m-cu at near midlength, a little shorter than the distal section of Cu_1; anal veins nearly parallel at origin, vein 2d A gently sinuous.

Abdominal tergites dark brown, the sternites more bicolored, the bases and apices of the individual segments yellow, the former more broadly so, the intermediate portion dark brown. Ovipositor and genital segment reddish yellow, the base of the sternal valves blackened; tergal valves relatively small and slender, upcurved.

LUZON, Laguna Province, above Majayjay, Mount Banahao, April 24, 1928 (*A. C. Duyag*).

This interesting *Libnotes* is named in honor of the collector, Mr. A. C. Duyag, who has collected many interesting species of Tipulidæ. By Edwards's key to the species of this subgenus,[10] the present species would run to *L.* (*L.*) *megalops* (Edwards), of Borneo. The latter differs in the uniformly ocherous thorax, brown halteres, and details of the wing pattern and venation.

LIMONIA (LIMONIA) IMPERSPICUA sp. nov. Plate 1, fig. 8.

General coloration reddish brown, the præscutum with a darker brown median stripe; legs brownish black, the femoral bases yellow; wings with a brownish suffusion, the costal margin narrowly dark brown; this continued outwardly to beyond the wing tip; male hypopygium with the rostral prolongation of the ventral dististyle very long and slender, the two spines arising from a common tubercle placed at the base of the prolongation.

Male.—Length, about 8 millimeters; wing, 9.2.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum broken. Head dark gray, the anterior vertex lighter gray; eyes shrunken but apparently broadly contiguous above.

Mesonotal præscutum dark reddish brown, with a darker brown median stripe; scutum testaceous yellow, each lobe with a large brownish black area; scutellum dark brown, the base medially pale yellow; postnotum brownish black, the cephalic margin narrowly paler. Pleura pale brownish yellow, with a conspicuous brownish black girdle that includes the anepisternum and sternopleurite; propleura less distinctly infuscated; a dark spot on the ventral pleurotergite. Halteres pale, the knobs infuscated. Legs with the coxæ brownish yellow, the fore coxæ brownish black at base; trochanters obscure yellow; femora dark brown, the bases narrowly yellow, the tips very vaguely pale; remainder of legs black; claws elongate, with a single long basal spine. Wings (fig. 8) with a brownish suffusion, cells C and Sc still darker, the color continued as a narrow costal seam to beyond the wing tip; stigma small, oval, darker brown; small vague brown seams at origin of Rs, along the cord, and in the axillary region; veins dark brown. Venation: Sc_1 ending about opposite two-thirds the length of Rs, Sc_2

[10] Loc. cit.

at its tip; Rs nearly straight beyond base, the distal third more arcuated; free tip of Sc_2 in alignment with R_2; cell 1st M_2 about as long as vein M_3 beyond it; a small spur jutting basad into cell 1st M_2 at the bend of M_3; m-cu at fork of M, a little longer than the distal section of Cu_1.

Abdomen dark brown, the caudal margins of the segments slightly paler; hypopygium dark. Male hypopygium with the ninth tergite transverse, the caudal margin evenly rounded, only vaguely emarginate medially. Basistyle with the mesal lobe relatively large and conspicuously setiferous. Ventral dististyle fleshy, the rostral prolongation slender, chitinized, the two spines placed at the base of the prolongation, arising from a common tubercle, gently curved, shorter than the prolongation alone; face of style near prolongation with a long, fleshy lobe that terminates in two long setæ. Dorsal dististyle a slender, angularly bent, chitinized rod that narrows gradually to the slightly decurved acute tip. Gonapophyses extensive, broad-based, narrowed gradually to the more slender apical points.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, June 2, 1928 (*R. C. McGregor*); holotype, male.

The peculiar structure of the male hypopygium is approached by *Limonia* (*Libnotes*) *termitina* (Osten Sacken), another fact in the long chain that has been accumulated to prove the close relationship existing between the various groups of limoniine Tipulidæ.

LIMONIA (EUGLOCHINA) PROJECTA sp. nov. Plate 1, figs. 9 and 9a.

General coloration dark brown; proximal ends of basitarsi blackened; wings elongate, cuneiformly narrowed at base, suffused with brown, especially on the costal and apical portions; Sc_2 ending opposite the end of vein 2d A; cell M_3 lost by the complete atrophy of m and both sections of vein M_3.

Male.—Length, about 6.5 to 8 millimeters; wing, 6 to 7.5.

Female.—Length, about 6 to 6.5 millimeters; wing, 6 to 7.

Rostrum and palpi dark brown. Antennæ with the scapal segments brown, the flagellum somewhat darker; flagellar segments elongate-fusiform, the longest verticils unilaterally arranged. Head black, the anterior vertex broad, more silvery.

Mesonotum dark brown, the pleura more yellowish testaceous. Halteres elongate, pale, the outer end of the stem and the knobs dark brown. Legs with the coxæ and trochanters yellowish

testaceous; femora and tibiæ black; basitarsi black at base, the remainder of tarsi snowy-white. Wings (figs. 9, 9*a*) long and narrow, the basal pedicel unusually long; membrane with a brownish suffusion, the costal region and apex darker brown; stigma long-oval, dark brown; veins black, the obliterative areas extensive. Venation: Sc short, ending opposite or just before the level of the end of vein 2d A, Sc_2 at the extreme tip of Sc_1; cord lying unusually far distad, at or beyond five-sixths of the length of the wing; Rs short, less than the angulated basal section of R_{4+5}; free tip of Sc_2 and R_2 in alignment; cell M_3 lacking by the atrophy of m and both sections of vein M_3; m-cu more than one-half its length beyond the fork of M; Cu_2 lacking.

Abdomen brownish black, including the hypopygium.

TABLAS, Badajoz, August 21, 1928 (*Francisco Rivera and A. C. Duyag*); holotype, male; allotype, female; August 20 to 27, 1928, nine paratopotype males and females. ROMBLON, August 16, 1928 (*Francisco Rivera and A. C. Duyag*), paratype male.

Limonia (*Euglochina*) *projecta* marks the extreme tendency of venation in the subgenus. The cord lies far distad and cell M_3 is entirely lacking by the atrophy of m and both sections of vein M_3, the latter condition being identical with the subgenus *Alexandriaria* Garrett. I have seen another species of *Euglochina* from Sumatra with the same peculiar venation.

HELIUS (HELIUS) ARCUARIUS sp. nov. Plate 1, fig. 10.

General coloration brownish yellow, the pleura clearer yellow; rostrum relatively long and slender; antennæ black throughout; legs brownish black, the tarsi paling into yellowish brown; wings subhyaline, the costal margin narrowly infuscated; R_{2+3} long, strongly arcuated at origin, beyond the base running parallel to R_1 or nearly so, this part of cell R_1 greatly narrowed; cell 1st M_2 long, m-cu near its base.

Male.—Length (excluding rostrum), about 4.5 millimeters; wing, 5.6; rostrum alone, about 0.7.

Rostrum relatively long and slender, approximately twice the remainder of the head, brownish black; palpi black. Antennæ longer than the rostrum, black throughout; flagellar segments long-oval, with an abundant erect pubescence. Head black.

Mesothorax almost uniformly brownish yellow, the dorsum darker medially, the pleura clearer yellow. Halteres dark brown, the base of the stem narrowly pale. Legs long and slender, the coxæ and trochanters obscure yellow; femora and tibiæ brownish black, the femoral bases narrowly paler; tarsi

paling to yellowish brown. Wings (fig. 10) subhyaline, cells C and Sc and the stigmal region infuscated to produce a dark costal border; veins brown. Venation: Sc_2 ending shortly beyond r-m, Sc_1 indistinct; Rs gently arcuated; R_{2+3} long, strongly arcuated at origin, beyond the base lying close to R_1, this part of the cell being narrow and generally parallel-sided; cell R_1 at margin a little more than one-third cell R_3; r-m just beyond the fork of Rs; cell 1st M_2 long-rectangular, shorter than the veins issuing from it; m-cu just beyond the fork of M, near the base of cell 1st M_2.

Abdominal tergites dark brown, the sternite obscure yellow; hypopygium dark. Male hypopygium with a conspicuous setiferous lobe on mesal face of basistyle, much as in most species of *Limonia*. Outer dististyle shorter than the inner, narrowed to the simple obtuse apex. Gonapophyses with the mesal hook very long and conspicuous.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, June 3, 1928 (*R. C. McGregor*); holotype, male.

Helius arcuarius is a very distinct species, in the darkened costal margin of the wing agreeing most closely with *H. fumicosta* Edwards, an otherwise entirely different fly. In the peculiar arcuation of vein R_{2+3}, it agrees with *H. longinervis* Edwards, a member of the subgenus *Eurhamphidia* Alexander, with r-m placed before the fork of Rs. The genus *Helius* includes a wide range of types, some of which well warrant subgeneric separation.

LECHRIA LUZONICA sp. nov. Plate 1. fig. 11.

General coloration shiny chestnut brown, the pleura more yellowish; antennæ black, the first scapal segment yellow; head dark gray; legs brownish black; cell 1st M_2 of moderate length; m-cu about one and one-half times its length beyond the fork of M and some distance before the level of r-m.

Male.—Length, about 5 millimeters; wing, 5.5.

Female.—Length, about 6 millimeters; wing, 7.

Rostrum brownish yellow; palpi brownish black. Antennæ with the first scapal segment yellow, the remainder of the organ black; flagellar segments suboval. Head dark gray; eyes above broadly contiguous.

Mesonotum shiny chestnut brown, the pleura more yellowish. Halteres brown, the base of the stem yellowish. Legs with the coxæ and trochanters yellowish; femora brownish black, the

bases narrowly and vaguely paler; tibiæ and tarsi dark brown. Wings (fig. 11) subhyaline, the costal region more yellowish; veins brownish black, C, Sc, and R paler. Venation: Sc_2 at tip of Sc_1, both lying shortly beyond the fork of Rs; cell 1st M_2 relatively short (as compared with *L. philippinensis*); m-cu about one and one-half times its length beyond the fork of M, at about one-third the lower face of cell 1st M_2; r-m lying distinctly distad of m-cu.

Abdominal tergites dark brown medially, paler brownish yellow laterally; sternites obscure yellow; eighth segment blackened; male hypopygium brownish yellow.

LUZON, Bulacan Province, San Jose del Monte, July 8, 1928 (*R. C. McGregor*); holotype, male; allotype, female; paratypes, three males and females.

Lechria luzonica seems to be most closely allied to *L. philippinensis* Alexander, despite the appearance of cell 1st M_2, which is more like the normal condition in the genus. From *L. lucida* de Meijere and *L. bengalensis* Brunetti, it differs notably in the coloration of the body and legs, as well as in the details of venation. A figure of the venation of *Lechria philippinensis* Alexander (fig. 12) is given for comparison.

Key to the Philippine species of Lechria Skuse.

Wings (fig. 12) with the costal cell brown; cell 1st M_2 very long and narrow, m-cu only a short distance before the level of r-m, fully twice its length beyond the fork of M; abdominal segments obscure yellow, at base narrowly cross-banded with brown.
L. philippinensis Alexander.

Wings (fig. 11) with the costal cell yellowish; cell 1st M_2 of normal size, m-cu some distance before the level of r-m, about one and one-half times its length beyond the fork of M; abdominal tergites obscure yellow with a brown dorsomedian stripe; sternites uniformly yellow .... *L. luzonica* sp. nov.

ERIOCERA FLAVIDIBASIS sp. nov.

General coloration brownish black, sparsely pruinose; antennal scape black, the flagellum brownish yellow; legs entirely brownish black; wings dark brown, the broad base and a conspicuous discal area yellow; cell M_1 present but tending to be evanescent by atrophy; abdomen brownish black.

Male.—Length, about 11 millimeters; wing, 14.

Rostrum and palpi black. Antennæ short, the scapal segments black, sparsely dusted with gray; flagellum conspicuously brownish yellow, the outermost segments a little darker. Head dull brownish gray.

Mesonotum dark brownish gray, the præscutum with three more glabrous, nearly concolorous stripes. Pleura brownish black, dusted with gray, the pleurotergite transversely ribbed with finer lines. Halteres brownish black. Legs entirely brownish black, all legs relatively stout. Wings strongly suffused with brown; wing base broadly light yellow, the color including all the prearcular region, the basal third of cell C and the narrower bases of cells Sc, 1st A, and 2d A, the former a little deeper in color than the two latter; the discal pale area relatively narrow in cell R_1, slightly wider behind, not crossing Cu, pale yellow in color. Venation: Cell M_1 present, in both wings of the type, vein M_1 represented only by a basal spur, the apex atrophied; m-cu beyond midlength of cell 1st M_2, about twice the distal section of Cu_1.

Abdomen brownish black, subnitidous, the caudal margins of the tergites narrowly paler; hypopygium black, with long conspicuous yellow setæ.

LUZON, Mountain Province, Benguet, Adaoay, April, 1924; holotype, male.

By Edwards's key to the Philippine species of *Eriocera*,[11] *E. flavidibasis* runs to couplet 9. It agrees with *E. griseicollis* Edwards in the retention of cell M_1 and the stout legs, differing in the coloration of the body, antennæ, and wings. From *E. crassipes* Bezzi, the present species differs in the stout fore and middle legs, the general coloration and venation.

ERIOCERA GLABRIVITTATA sp. nov.

General coloration black, the mesonotal præscutum velvety black, the usual three stripes shiny plumbeous black; femora yellow, the tips broadly blackened; wings broad, the base, especially in the anal cells, and a broad discal area whitish; cell M_1 lacking; abdominal tergites subnitidous, blue-black; basal shield of ovipositor brown, densely covered with an appressed golden pubescence.

Female.—Length, about 16 millimeters; wing, 15.

Rostrum and palpi black. Antennæ broken. Head black, sparsely pollinose.

Mesonotal præscutum velvety black, the usual three stripes separate, shiny plumbeous black; centers of the scutal lobes similarly glabrous; scutellum black, sparsely pruinose. Pleura black. Halteres brownish black. Legs with the coxæ and trochanters black; femora yellow, the tips broadly blackened; tibiæ

[11] Notulae Entomologicae 6 (1926) 38–39.

black, on at least one leg (detached) just beyond the base and extending for about one-half the length of the sclerite brownish yellow; tarsi black. Wings broad, suffused with dark brown, the prearcular region extensively brighter, almost whitish, in the costal region passing beyond h; bases of both anal cells broadly whitened, the remainder of these cells grayish; a broad, conspicuous, whitish crossband before the cord, this generally parallel-sided, extending from R to Cu; veins pale brown, more yellowish in the discal pale area. Venation: Cell M_1 lacking; m-cu immediately before midlength of cell 1st M_2.

Abdominal tergites blue-black, subnitidous, without pale markings; sternites more reddish brown. Ovipositor with the dorsal shield brown, densely covered with an appressed golden pubescence; valves elongate, slender, reddish horn color.

LUZON, Mountain Province, Benguet, Pauai (Haight's place), altitude about 2,450 meters, April 1, 1925 (*Francisco Rivera*); holotype, female.

By means of Edwards's key to the Philippine species of *Eriocera*,[12] the present species runs to couplet 3, disagreeing with both included species in the diagnostic characters indicated above.

ERIOCERA CARBONIPES sp. nov.

General coloration of head and thorax dark grayish black, the præscutum with three glabrous plumbeous black stripes that are confluent behind; legs and halteres entirely black, the former relatively slender; wings dark brown, the bases of the anal cells and a conspicuous area before the cord white; cell M_1 lacking; abdomen shiny blue-black, the hypopygium black.

Male.—Length, about 12 millimeters; wing, 12.8.

Rostrum and palpi black. Antennæ with the scape black; flagellum broken. Head dull grayish black.

Mesonotal præscutum dull black, with three shiny plumbeous black stripes that are entirely confluent behind, the humeral inter-spaces being restricted to elongate triangles; posterior sclerites of mesonotum similarly dark leaden gray. Pleura black, sparsely pruinose, especially on the pleurotergite. Halteres black. Legs relatively slender, entirely black. Wings dark brown, the bases of the anal cells broadly whitened; costal cell before h a little pale; a conspicuous white discal area before cord, extending from vein R_1 to Cu_1; veins dark brown. Vena-

[12] Loc. cit.

tion: Cell M_1 lacking; m-cu at midlength of cell 1st M_2, more than twice the distal section of Cu_1.

Abdomen shiny blue-black, the hypopygium black.

LUZON, Mountain Province, Ifugao, Kiangan, altitude about 1,000 meters, March, 1925 (*Francisco Rivera*); holotype, male.

By Edwards's key to the Philippine species of *Eriocera*,[13] the present species runs to couplet 9, disagreeing with both included species in the slender legs. It closely resembles *E. glabrivittata* sp. nov., differing most conspicuously in the entirely black legs.

TRENTEPOHLIA (MONGOMA) LUZONENSIS Edwards. Plate 1, fig. 13.

Trentepohlia (Mongoma) luzonensis EDWARDS, Notulae Entomologicae 6 (1926) 37–38.

Edwards's unique type, a female, was from Mount Banahao, collected in June, 1914, by Boettcher. I have seen a few additional specimens of both sexes from the same locality, collected above Majayjay, by Mr. A. C. Duyag. The male sex has not been described and is herewith characterized as allotype. The present material is in better preservation than the type and a few additional facts are noted.

Female.—Length, 13 millimeters; wing, 9; fore leg, femur, 12.5; tibia, 16.2; tarsus, about 12.5; hind leg, femur, 13.5; tibia, 14.2; tarsus, about 8.5.

Allotype.—Male. Antennæ with the basal segment dark brown, paler beneath; second segment obscure yellow; basal segment of flagellum yellowish, the outer segments darkened; flagellar segments elongate, without long conspicuous verticils.

Mesonotal præscutum chiefly yellow, the broad lateral margins blackened; a narrower median black vitta begins behind the cephalic margin and ends before the suture, being replaced by a pale yellow vitta that continues backward onto the postnotum; scutal lobes extensively blackened, the median area and scutellum more testaceous yellow. Pleura reddish yellow, the pteropleurite and posterior pleurotergite more blackened. Legs very long and slender, as shown by the above measurements. Wing (fig. 13) whitish hyaline, the costal margin yellow; veins black, C, Sc, and R conspicuously yellow; prearcular veins and the base of cell Cu_1 narrowly yellow; stigma dark brown; very narrow dark seams on m-cu and adjoining portions of vein Cu_1; a dark spot between anal veins near origin. Venation: Rs long and

[13] Loc. cit.

nearly straight; R_{2+3+4} long, gently sinuous; R_2 a little longer than R_{3+4}; tips of R_3 and R_4 pale; proximal end of cell M_3 a little basad of that of cell R_5; apical fusion of Cu_1 and 1st A slight.

Abdominal tergites chiefly dark brown, the outer segments more extensively brownish yellow; terminal segments blackened; sternites more yellowish, the caudal margins of the outer segments blackened.

The middle legs, broken in the type, have the tips of the tibiæ broadly blackened, as in the fore legs.

LUZON, Laguna Province, above Majayjay, Mount Banahao, May 10, 1928 (*A. C. Duyag*); allotype, male, and two additional specimens.

TRENTEPOHLIA (MONGOMA) POLIOCEPHALA sp. nov. Plate 1, fig. 14.

General coloration light yellow; head light gray; legs testaceous yellow, only the terminal tarsal segments slightly darkened; wings subhyaline, veins pale brown; cell 1st M_2 small; inner end of cell M_3 proximad of that of cell 2d M_2; apical fusion of veins Cu_1 and 1st A subequal to m.

Male.—Length, about 4 millimeters; wing, 4.6.

Female.—Length, about 4.8 millimeters; wing, 5.

Rostrum yellow, the palpi very slightly darker. Antennæ relatively long, in male, if bent backward, extending about to the base of the halteres; basal segments yellowish testaceous, the flagellar segments beyond the base dark brown; flagellar segments subcylindrical, gradually decreasing in size outwardly; verticils relatively inconspicuous. Head light gray, the anterior vertex very narrow.

Thorax entirely light yellow, unmarked. Halteres short, pale yellow. Legs with the coxæ and trochanters pale yellow; remainder of legs testaceous yellow, the terminal tarsal segments scarcely darkened; a few conspicuous long black setæ at tips of femora. Wings (fig. 14) subhyaline, the costal region slightly more yellowish; veins pale brown, those of the costal region slightly more yellowish. Venation: Rs a trifle longer than the basal section of R_5; R_2 about one-half its length before the fork of R_{3+4}; cell R_4 large; cell 1st M_2 small, irregularly hexagonal; basal section of M_3 long, arcuated, the inner end of the cell lying proximad of cell 2d M_2; m-cu about two-thirds its length before the fork of M; apical fusion of Cu_1 and 1st A subequal to m.

Abdomen brownish yellow, including the hypopygium, the caudal margins of the segments a little paler.

The allotype female is generally similar to the male, differing as follows: Pleura and abdomen darker, this probably caused by decomposition of tissues within the body; cell 1st M_2 a little more elongate.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, May 26, 1928 (*R. C. McGregor and Francisco Rivera*); holotype, male; allotype, female.

By the author's key to the Philippine species of *Trentepohlia*,[14] *T. poliocephala* runs to couplet 3, differing from both included species in the diagnostic characters as listed. In its pale yellow coloration and small size, the present form agrees with *T.* (*M.*) *flava* (Brunetti), of India. The latter species differs from all known members of the subgenus *Mongoma* in having the distal section of Cu_1 reaching the wing margin and not fused apically with 1st A.

TRENTEPOHLIA (MONGOMA) SAXATILIS sp. nov. Plate 1, fig. 15.

General coloration dark brown, the pleura obscure brownish yellow; legs very long and slender; femora dark brown, the tips abruptly pale yellow; tibiæ and tarsi pale; wings with a faint dusky tinge, cells C and Sc a little darker; vein R_3 conspicuously arcuated, the inner end of the cell being broadly obtuse; cell 1st M_2 relatively short; inner end of cell R_5 proximad of cells 2d M_2 or M_3; apical fusion of veins Cu_1 and 1st A short.

Male.—Length, about 8 millimeters; wing, 8; fore leg, femur, 12; tibia, 15.8; tarsus, about 16; middle leg, femur, 14; tibia, 14.5; tarsus, about 14. Other males show the following measurements: Length, 8 to 9 millimeters; wing, 8 to 9.

Female.—Length, 10 to 11 millimeters; wing, 9 to 10.

Rostrum yellow; maxillary palpi dark brown. Antennæ dark brown. Head dark gray, the vertex with a conspicuous median carina.

Pronotum brown, paler laterally. Mesonotum dark brown, the humeral region of præscutum narrowly yellow; median region of scutum obscure yellow. Pleura obscure brownish yellow, the dorsopleural region dusky. Halteres dark brown, the extreme base of the stem yellow. Legs very long and slender, as shown by the above measurements; coxæ and trochanters yellowish testaceous; femora dark brown, their bases restrictedly pale, their tips abruptly and rather broadly (1.2 millimeters) pale yellow; tibiæ and tarsi dirty white to pale yellow, the tibiæ beyond base very vaguely darkened; no con-

[14] Philip. Journ. Sci. 33 (1927) 302.

spicuous setal adornments on legs. Wings (fig. 15) with a faint dusky tinge, cells C and Sc a little darker; wing apex narrowly darkened; space between branches of Cu darkened; some of the longitudinal veins vaguely seamed with brown; veins dark brown. Venation: R_2 about its own length before the fork of R_{3+4}; R_3 conspicuously arcuated, the inner end of the cell broadly obtuse; cell 1st M_2 relatively short, the veins beyond it correspondingly elongated; inner end of cell R_5 proximad of the other cells beyond cell 1st M_2; inner ends of cells 2d M_2 and M_3 nearly in alignment, subequal; apical fusion of Cu_1 and 1st A short to very short.

Abdominal tergites dark brown; sternites obscure brownish yellow; hypopygium dark.

LUZON, Laguna Province, above Majayjay, Mount Banahao, altitude over 500 meters, May 26 to 29, 1928 (*R. C. McGregor*); holotype, male; allotype, female; paratypes, twelve males and females.

By the author's key to the Philippine species of *Trentepohlia*,[15] the present species runs to *T.* (*M.*) *tenera* (Osten Sacken) in couplet 2. It is a larger species, with very long legs, the femoral tips abruptly pale; vein R_3 arcuated, the inner end of the cell obtuse; inner end of cell R_5 lying proximad of the other cells beyond 1st M_2, and other characters.

The following detailed notes on the occurrence of the species are of unusual interest and value:

"May 28, 1928. On sides of damp rocks, adjoining a small stream. About a dozen, clustered on dark side of a damp rock, just above a mountain stream. They vibrate up and down, as do many other species of this family of flies.

"May 29, 1928. Crane flies on damp, more or less mossy rocks along small forest stream. One, two, or three flies together on vertical or overhanging side of rock, the surface damp and more or less covered with short moss. Water usually directly underneath the flies. The flies are not easily disturbed and can be captured with a wide-mouthed bottle. They never cease their rather fast rocking motion. When disturbed, they fly only a short distance, but take a long time before settling on a rock again. In two cases, only, I saw them hanging from fern leaves, in copulation. I disturbed one pair before I realized the conditions. The second pair I watched for ten minutes, but could not detect much because the upper fly was continually in motion and this moved the lower fly. The larger individual (female) hung with from two to four feet on the pinnæ of a drooping fern frond. The smaller (male) seemed to hang with the legs in the opposite direction."—R. C. MCGREGOR. A sketch from life

[15] Loc. cit.

of this pair shows the female with the front pair of legs holding to two separate fern pinnæ, one additional middle leg similarly holding to a third pinna. The other legs hang free. The small male hung suspended, with all legs hanging free and in the opposite direction from those of his mate. This would seem to indicate that in mating, the genitalia are so twisted that the venter of the male lies on the same side as the dorsum of his mate.

"May 28, 1928. A few, on leaves of shrubs, usually on underside of leaf, one or two of this and related flies [as *Trentepohlia pennipes* Osten Sacken, *T. trentepohllii* Wiedemann, etc.] on a single leaf."—R. C. McGregor and Francisco Rivera.

TRENTEPOHLIA (TRENTEPOHLIA) BAKERI Alexander.

Trentepohlia (Trentepohlia) bakeri Alexander, Philip. Journ. Sci. 33 (1927) 304–305.

The unique type, a female, was from Mount Maquiling, Luzon, collected by Baker. A considerable series of specimens has recently been sent me by Mr. McGregor, taken at Binauañgan, Obando, Bulacan Province, Luzon, December 29, 1927, where they were found resting on leaves and twigs of mangroves (*R. C. McGregor*). Associated with this species were a lesser number of *Limonia (Geranomyia) circipunctata* Brunetti.

The present extensive series indicates the following range of characters: Rostrum, in some specimens, much paler than the palpi, obscure yellow. In most specimens, the mesonotal præscutum trivittate with brown, the lateral stripes being well indicated and separate from the median area. Besides the stigmal area, Cu, the cord, fork of R_{3+4} and vein R_5 are distinctly bordered by grayish. Sc_2 usually close to the tip of Sc_1, in some cases at some distance from this tip, Sc_1 alone being approximately one-third the length of Rs.

TRENTEPOHLIA (TRENTEPOHLIA) HOLOXANTHA sp. nov. Plate 1, fig. 16.

General coloration of thorax and abdomen yellow, unmarked; head light gray, carinate; halteres and legs yellow; wings with a yellow suffusion, especially on the costal and apical portions; male hypopygium brownish black.

Male.—Length, about 7 millimeters; wing, 6; middle leg, femur, 10.7; tibia, 11; tarsus, about 6.

Rostrum and palpi brownish yellow. Antennæ obscure brownish yellow, the outer segments of the flagellum somewhat darker. Head light gray, the posterior vertex variegated with darker gray; posterior vertex carinate.

Thorax entirely shiny yellow, without markings. Halteres yellow. Legs yellow, only the four outer tarsal segments black-

ened. Wings (fig. 16) with a yellowish suffusion, the costal region and apex more-saturated yellow; veins yellow. Venation: Sc_2 lacking; R_{1+2} and R_3 likewise very weak and relatively indistinct; Rs relatively short, about two-thirds the basal section of R_5; R_{2+3+4} strongly approaching R_1, R_2 being very short and faintly preserved; beyond R_2, R_{3+4} bends strongly caudad; R_3 oblique; inner end of cell R_5 acute; apical fusion of Cu_1 and 1st A very short.

Abdomen yellow, the hypopygium brownish black.

SIBUYAN, San Fernando, August 9, 1928 (*Francisco Rivera and A. C. Duyag*); holotype, male.

Trentepohlia holoxantha differs strikingly from all described species of the genus in the coloration and venation. The characters of carinate vertex, stout body, and long stout legs are noteworthy in the subgenus.

TEUCHOLABIS (TEUCHOLABIS) CONFLUENTA Alexander. Plate 1, fig. 17.

Teucholabis confluenta ALEXANDER, Philip. Journ. Sci. 27 (1925) 75–76.

The types were from Mount Maquiling, collected by Baker. An additional male was taken by Francisco Rivera, at Mount Irid, Rizal, Luzon, December, 1926. The wing of this species has never been figured and is shown on Plate 1, fig. 17.

CERATOCHEILUS ROMBLONENSIS sp. nov. Plate 1, fig. 18.

General coloration rich brown; pleura yellow with a broad black dorso-longitudinal stripe; legs black; wings subhyaline, cells C and Sc infumed; R_{2+3+4} short, nearly perpendicular; cell M_2 open by the atrophy of m; abdominal tergites dark brown, the caudal margins narrowly pale; sternites obscure yellow.

Female.—Length, excluding rostrum, about 5.5 to 6 millimeters; wing, 4.3 to 4.5; rostrum alone, about 5.8 to 6.

Rostrum (female) approximately as long as the remainder of the body. Antennæ black throughout. Head dark gray, clearer gray on the anterior vertex and posterior orbits. Anterior vertex narrow, slightly less than the diameter of the first scapal segment.

Pronotum black. Mesonotal præscutum rich brown, the lateral margin narrowly pale, scutum brown, the median region more yellowish; scutellum and postnotum darker brown, the latter more pruinose. Pleura pale yellow with a broad dorsal black stripe, extending from the pronotum across the dorsal pleurites and dorsopleural membrane, passing through the root

of the halteres to the abdomen, the ventral margin straight and clearly delimited. Halteres yellow, the knobs dark brown. Legs with the coxæ and trochanters pale yellow; remainder of legs black. Wings (fig. 18) subhyaline, cells C and Sc infumed; veins black. Venation: Sc_1 ending about opposite one-third to one-fourth the length of Rs, Sc_2 some distance from its tip, opposite or shortly before the origin of Rs; R_{2+3+4} nearly perpendicular at origin, cell R_1 at margin narrow; cell M_2 open by atrophy of m; vein M_3 strong, arcuated; vein M_4 weak; m-cu about one-third its length before the fork of M.

Abdominal tergites dark brown, the caudal margins of the outer segments narrowly paler to produce an annulate appearance; sternites obscure yellow; genital shield dark; ovipositor with the valves dark horn color, very long and nearly straight.

TABLAS, Badajoz, August 27, 1928 (*Francisco Rivera and A. C. Duyag*); holotype, female; paratypes, two females.

Ceratocheilus romblonensis differs from all regional species by the open cell M_2. The anterior vertex is narrow, without corniculus.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Scamboneura primæva* sp. nov., wing.
2. *Scamboneura psarophanes* Alexander, wing.
3. *Macgregoromyia benguetensis* gen. et sp. nov., wing.
4. *Limonia* (*Libnotes*) *igorota* sp. nov., wing.
5. *Limonia* (*Libnotes*) *banahaoensis* sp. nov., wing.
6. *Limonia* (*Libnotes*) *riverai* sp. nov., wing.
7. *Limonia* (*Libnotes*) *duyagi* sp. nov., wing.
8. *Limonia* (*Limonia*) *imperspicua* sp. nov., wing.
9. *Limonia* (*Euglochina*) *projecta* sp. nov., wing; 9*a*, wing apex, enlarged.
10. *Helius* (*Helius*) *arcuarius* sp. nov., wing.
11. *Lechria luzonica* sp. nov., wing.
12. *Lechria philippinensis* Alexander, wing.
13. *Trentepohlia* (*Mongoma*) *luzonensis* Edwards, wing.
14. *Trentepohlia* (*Mongoma*) *poliocephala* sp. nov., wing.
15. *Trentepohlia* (*Mongoma*) *saxatilis* sp. nov., wing.
16. *Trentepohlia* (*Trentepohlia*) *holoxantha* sp. nov., wing.
17. *Teucholabis* (*Teucholabis*) *confluenta* Alexander, wing.
18. *Ceratocheilus romblonensis* sp. nov., wing.

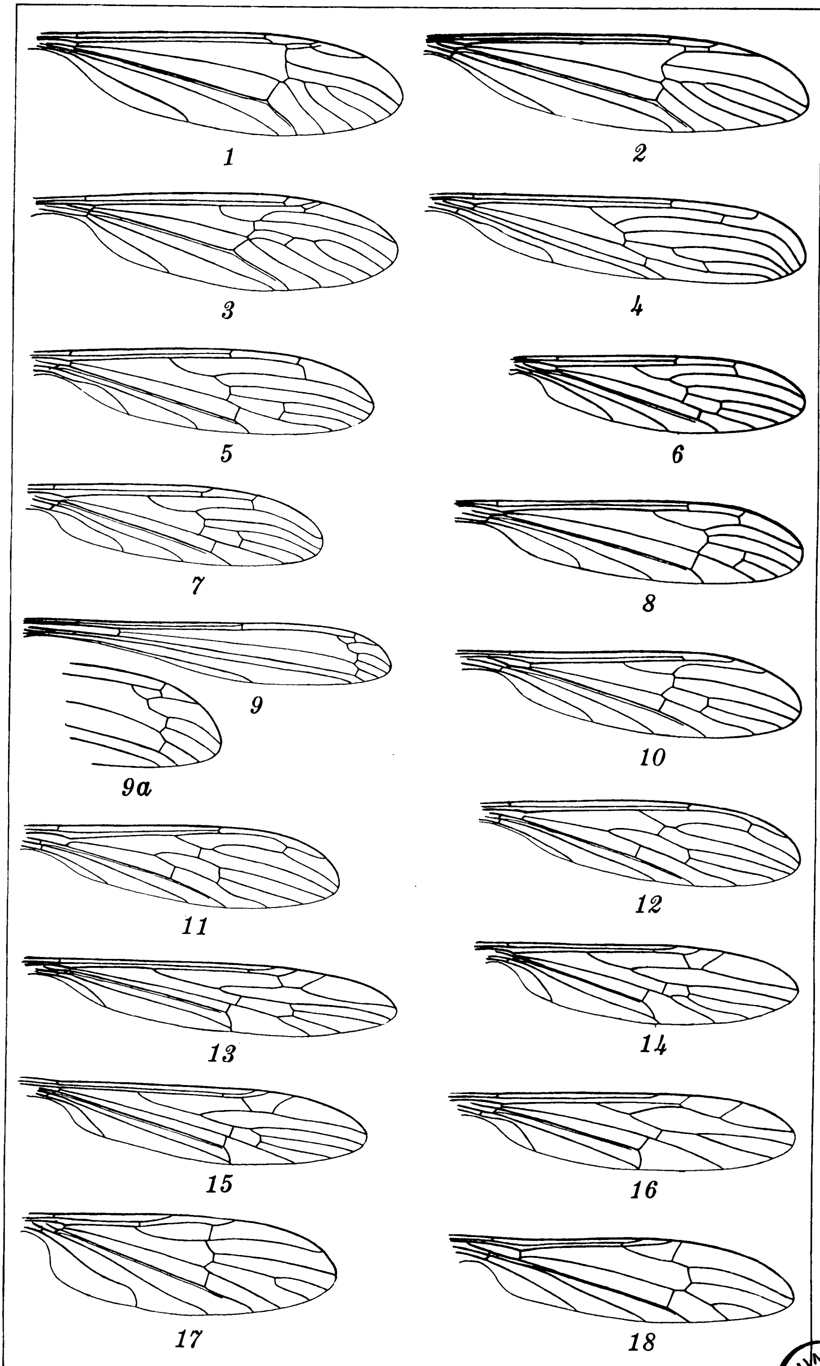

PLATE 1.

COMPOSITION OF PHILIPPINE BAGASSE

By ABELARDO VALENZUELA and AUGUSTUS P. WEST
Of the Bureau of Science, Manila

During the year 1926-1927, about 4,064,698 tons of sugar cane were ground in the Philippines.[1] Since about 24 per cent of the sugar cane consists of the woody fiber (bagasse), then about 973,500 tons of bagasse were produced. In the Philippines, bagasse is regarded as a waste by-product and is used principally as fuel. Experiments carried out by chemists in the Bureau of Science, Manila, have shown that a good grade of wall board can be made from Philippine bagasse. Researches on Hawaiian bagasse[2] have shown that the bagasse is also useful for making paper. If bagasse could be used for making other commercial products, such as rayon (artificial silk), it would be a very desirable material since large quantities of bagasse are produced annually at the various sugar centrals.

The chemical composition of wood is quite variable and depends upon various factors, such as the kind of wood, age, season, and the location where it is grown. Since wood from different sources shows usually a wide range in composition, it seemed desirable to make a preliminary investigation of Philippine bagasse to determine its various constituents.

EXPERIMENTAL PROCEDURE

The bagasse used in these experiments was made from the Luzon white variety of sugar cane which was obtained from the Calamba Sugar Estate, Laguna, Philippine Islands.

In preparing wood samples for analysis, it is usually customary to get the material in the form of a wood powder fine enough to pass an 80-mesh screen. With the grinding machines at our disposal, we found it difficult to prepare bagasse samples of such a degree of fineness. The method finally adopted was

[1] Compilation of Committee Reports for the Fifth Annual Convention of the Philippine Sugar Association, Manila, 1927.

[2] Little, A. D., Report of the Experiment Station of the Hawaiian Sugar Planters' Association, Bull. 46 (1919).

that of cutting the bagasse into small pieces about 3 millimeters in length, passing the cut material through a grinding machine, and then sieving it.

TABLE 1.—*Fineness of bagasse.*

Mesh.	Bagasse passed. Per cent.
20	61.29
35	33.22
48	3.28

The figures given in Table 1 show the percentage of bagasse which passed screens of different mesh. Only a very small percentage (3.28) of the bagasse passed a 48-mesh screen. This material seemed to be mostly pith and appeared to contain very little fiber. Samples for analysis were selected from the material which passed the 20- and 35-mesh screens. Material passing the 48-mesh screen was discarded.

ANALYSIS

In estimating the principal constituents of Philippine bagasse, in general, the methods given by Schorger [3] were followed. This was especially true for the determination of moisture, cold-water soluble ingredients, hot-water soluble, alkali soluble, ether extract, alcohol extract, ash, nitrogen, pentosans, and copper number. Samples which had passed 20- and 35-mesh screens were used instead of samples which had passed an 80-mesh screen as Schorger recommended. Schorger's method was employed for the determination of alpha cellulose but, as the result appeared to be somewhat high, the Cross and Bevan method [4] was also used. This gave considerably lower results. Probably the correct figures would be somewhere between the results given by these two methods.

There appears to be no accurate method for the determination of lignin. Several methods were tried with indifferent results as shown by the data given in Table 2.

The hydrochloric acid method of Krull [5] and the sulphuric acid method of Mahood and Cable [6] appear to give results which are considerably too high. Moreover, the samples of lignin

[3] The chemistry of Cellulose and Wood (1926) 505–555.

[4] Cross, C. F., and E. J. Bevan, A Text-book of Paper Making (1920) 62.

[5] Schorger, A. W., The Chemistry of Cellulose and Wood (1926) 519.

[6] Mahood, S. A., and D. E. Cable, Journ. Ind. Eng. Chem. 14 (1922) 934.

obtained by these methods did not appear to be of good quality as they were black and charred, and insoluble in acetone. The lignin obtained by the Philipps[7] method was an amorphous brown powder, soluble in acetone. Detailed results of the Philipps method are given in Table 3.

TABLE 2.—*Determination of lignin in bagasse.*

[Figures not calculated on a moisture-free basis.]

Mesh.	Lignin.		
	Method of Krull.	Method of Mahood and Cable.	Method of Philipps.
	Per cent.	*Per cent.*	*Per cent.*
20	30.42	30.68	14.93
35	32.90	31.85	16.45

TABLE 3.—*Determination of lignin in bagasse by the fractional extraction method of Max Philipps.*

[Figures not calculated on a moisture-free basis.]

Mesh.	Fraction.				Total lignin.
	1	2	3	4	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
20	7.40	4.26	2.39	0.88	14.93
35	8.06	5.14	2.53	0.72	16.45

These fractions were obtained by extracting the bagasse first with alcohol-benzene solution to eliminate substances such as waxes and resins. The residue was then extracted successively with 2 per cent alcoholic sodium hydroxide (fraction 1), 2 per cent aqueous sodium hydroxide (fraction 2), 2 per cent sodium hydroxide at 135° C. (fraction 3), and 4 per cent aqueous sodium hydroxide at 180° C. (fraction 4). The results show that, by the Philipps method, a 20-mesh sample of Philippine bagasse gave a total of 14.93 per cent lignin, and a 35-mesh sample gave 16.45 per cent. According to this method the total lignin content of Philippine bagasse varies from about 14.93 to 16.45 per cent.

Pectin was determined by the method of Carré and Haynes,[8] which consists in estimating the pectin as calcium pectate.

[7] Philipps, Max, Journ. Am. Chem. Soc. 50 (1928) 1986.

[8] Carré, M. H., and D. M. Haynes, Biochem. Journ. 16 (1922) 63.

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The results obtained by analyzing Philippine bagasse according to the methods adopted are given in Table 4.

TABLE 4.—*Analysis of Philippine bagasse.*

[Figures showing the percentage of cellulose, pentosans, lignin, pectin, and ash were calculated on the moisture-free basis.]

	Mesh.	
	20	35
Cellulose:	*Per cent.*	*Per cent.*
(Cross and Bevan)	51.02	48.71
(Schorger)	69.14	63.80
Pentosans	23.13	22.83
Lignin (Philipps)	16.65	18.34
Pectin	1.77	1.83
Ash	3.58	5.85
Ether extract	0.42	0.66
Alcohol extract	2.13	2.00
Cold-water soluble	10.20	11.65
Hot-water soluble	14.93	15.25
Alkali soluble (1 per cent sodium hydroxide)	35.67	36.93
Nitrogen	0.30	0.42
Copper number	8.20	8.70

According to Browne [9] average analyses of purified American bagasse gave 55 per cent cellulose, 24 per cent pentosans, and 15 per cent lignin. These figures compare favorably with the data given in Table 4.

Avram [10] gives figures showing the limit specifications for wood pulp suitable for the viscose-rayon industry. These figures are given in Table 5, together with the corresponding data obtained from the analysis of Philippine bagasse (Table 4).

According to Avram, wood pulp suitable for the viscose-rayon industry should have an alpha-cellulose content of not less than 85 per cent. The ash content should not be more than 0.3 per cent and the copper number not over 3. Our results show that the alpha-cellulose content of bagasse is not over 69.14 per cent, and probably it is considerably less than that. The percentage of ash and the copper number of bagasse are considerably greater than the limit specifications given for viscose-rayon pulp. The data obtained for Philippine bagasse does not meet the specifications of viscose-rayon pulp.

[9] La. Exp. Sta. Bull. 91; Deerr, N., Cane Sugar (1921) 454.

[10] Rayon Industry (1927) 109.

TABLE 5.—*Comparison of viscose-rayon wood-pulp specifications with corresponding data from Philippine bagasse.*

[Figures for the bagasse vary according to the fineness of the material.]

	Viscose rayon specifications.	Bagasse.
	Per cent.	*Per cent.*
Alpha cellulose (minimum)	85.0	48.71–69.14
Ash (maximum)	0.3	3.58– 5.86
Copper number (maximum)	3.0	8.20– 8.70

ALPHA CELLULOSE

Samples of alpha cellulose were prepared from Philippine bagasse. When tested this cellulose showed an ash content of 1.42 per cent and a copper number of 1.14. Although the ash percentage is somewhat higher than the viscose specifications, the copper number is considerably lower. Possibly the alpha cellulose, when isolated from the bagasse, may be suitable for the manufacture of various commercial products. We expect to carry out further experiments with this material.

In Table 6 is given the approximate composition of Philippine bagasse compiled from our analytical data.

TABLE 6.—*Approximate composition of Philippine bagasse.*

Constituent.	Bagasse.	
	20-mesh.	35-mesh.
	Per cent.	*Per cent.*
Moisture	10.33	10.30
Alpha cellulose (Cross and Bevan)	45.75	43.70
Pentosans	20.74	20.48
Lignin (Philipps)	14.93	16.45
Fat and wax (ether-alcohol extract)	2.55	2.66
Ash	3.21	5.25
Other non-nitrogenous substances by difference	2.49	1.16
Total	100.00	100.00

The results (Table 6) show that the bagasse analyzed contains about 16 per cent of lignin. Should lignin become an important commercial substance, bagasse might serve as a possible source of lignin.

NITRATION

Preliminary experiments were carried out on the nitration[11] of Philippine bagasse. The procedure was as follows:

In order to eliminate the fats, waxes, and resins the bagasse was first extracted with a mixture consisting of equal parts of alcohol and ether. The extracted bagasse was boiled in an autoclave with a 20 per cent solution of sodium hydroxide for five hours at a temperature of 160° C. The bagasse was then washed with water to free it from alkali. The moist bagasse was bleached with chlorine gas for half an hour, after which it was boiled with a 2 per cent sodium sulphite solution, washed with hot and then cold water, and dried. The bagasse (20 grams) was nitrated by treating it with a nitrating solution consisting of 87 cubic centimeters of concentrated nitric acid and 137 cubic centimeters of concentrated sulphuric acid. The flask containing the mixture was placed in a thermostat, and the mixture was stirred constantly at a temperature of about 45° C. for seven hours. The bagasse was washed with cold and hot water until free from acids and then dried. The yield of nitrocellulose was about 70 per cent. Analysis by the Kjeldahl method showed that the nitrocellulose contained 3.75 per cent nitrogen.

Similar experiments were carried out on the nitration of alpha cellulose prepared from bagasse. The alpha cellulose was nitrated for five hours at a temperature of 50° C. The yield of nitrocellulose was about 60 per cent, and the nitrogen content was 4.22 per cent. Since mono-nitrocellulose contains 3.8 per cent nitrogen, it would appear that the nitrocellulose preparations made consisted mostly of the mono-nitro derivative of cellulose.

A considerable proportion (about 80 per cent) of the nitrocellulose prepared from bagasse and also from the bagasse alpha cellulose was found to be very soluble in alcohol-ether mixture (1 : 3), acetone, and methyl alcohol. These solutions of the nitrocellulose when poured on glass plates and allowed to evaporate gave a residue somewhat like a transparent film which, when scratched, crumbled to a white powder.

These nitrocellulose preparations of bagasse, when ignited, burned with the quick flashing flame characteristic of nitrocellulose compounds.

Although a number of nitration experiments were performed under different conditions of temperature and concentration of

[11] Lunge, G., Journ. Am. Chem. Soc. 23 (1901) 527.

acids, it has not been possible to make a nitrocellulose containing more than 4.26 per cent nitrogen. The experiments seem to indicate that bagasse and the alpha cellulose prepared from bagasse are not nitrated very readily.

SUMMARY

Samples of Philippine bagasse were analyzed and the approximate composition determined. The results showed that bagasse contains about 45 per cent alpha cellulose (Cross and Bevan), about 20 per cent pentosans, and about 15 per cent lignin (Philipps).

Preliminary experiments were carried out on the nitration of bagasse and on the alpha cellulose prepared from bagasse. Our experiments seem to indicate that bagasse and the alpha cellulose prepared from bagasse are not nitrated very readily since the nitrocellulose we prepared did not contain more than 4.26 per cent nitrogen.

LABORATORY TESTING OF GERMICIDES AND CHEMOTHERAPEUTIC AGENTS

By OTTO SCHÖBL

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When the Philippine Leprosy Research Board was organized by the order of the late Governor-General, Leonard Wood, the part of the program dealing with laboratory investigation of the chemotherapeutic properties of various drugs and chemicals was assigned to me as a member of the board. These investigations were carried out for several years in collaboration with guest workers and members of the staff of the division. Following the footsteps of Walker and Sweeny we tested a long series of vegetable and volatile oils as well as a series of synthetic chemicals and other drugs.[1]

The problem was to establish the fundamental principles underlying the mechanism of the bacteriostatic property of the drugs in question, to study the relation between the structural formula of drugs and their bacteriostatic property in relation to acidfast bacteria, as well as to obtain the necessary information concerning the relative superiority of one chaulmoogra oil or its derivatives over the others. The results of our investigations were a valuable indication to the physician, as to what to expect in the clinic, and were an indispensable guide to the synthetic chemist. A large part of the success in securing new synthetic preparations in the chemotherapy of leprosy was due to the fact that the results of laboratory tests enable the chemist to feel his way more securely and quickly in his search for new and effective compounds.

As a result of laboratory experiments the mechanism of the bacteriostatic action of some vegetable oils was explained. It

[1] Chemotherapeutic experiments with chaulmoogra and allied preparations, I, II, III, IV, V, Philip. Journ. Sci. (December, 1923, to August, 1924). Semiselective antiseptic effect of the vapors of vegetable oils, essential oils, their constituents, and similar compounds, Philip. Journ. Sci. (April, 1925).

was found that the growing acid-fast bacteria saponified the vegetable oil and used only the carbohydrate part of the glycerides as a food and not the fatty acids as was previously claimed. Whether or not the oil will stimulate the growth of acid-fast bacilli, or inhibit it, depends upon the chemical residue of the saponification whether it is antiseptic or inert. It was found by these experiments that hydnocarpic acid is slightly superior to chaulmoogric acid. Independent of our experiments it was found by workers in India that wightiana oil, which has a high content of hydnocarpic acid, is superior to other chaulmoogra oils which have high content of chaulmoogric acid and low content of hydnocarpic acid. The addition of fresh serum to the medication tubes reduces the static effect of sodium salt of chaulmoogric and hydnocarpic acid much more than it lowers that of glycerides or other esters. In the clinic these sodium salts were found not to be superior to chaulmoogra oil, which was to be expected from the laboratory test. The results of tests without the serum showed enormous superiority over the oils and esters with regard to bacteriostatic action. The drop in the bacteriostatic effect of sodium gynocardate, due to the addition of serum, made it clear by simple calculation that impossible quantities of this drug would have to be injected intravenously to bring the concentration of the drug in the body liquids to the point found necessary by laboratory testing for instantaneous inhibition of growth. These laboratory experiments led one to expect little effect from this drug in doses allowed by the toxic limit which again was found by laboratory methods.

Having had these personal experiences and being acquainted with the writings of others who had worked along the same line, I came to the conclusion, as did others, both physicians and chemists, that laboratory tests are of great value to the physician engaged in medical research and that they are a part of the investigation indispensable to the synthethic chemist who is searching for new and more-effective remedies. I was, therefore, greatly impressed by an editorial [2] in which it is stated: "Whatever the final results of laboratory experiments may be reliance should not be placed solely on such results; clinical observations must be considered." The statement appears to insinuate that whenever laboratory methods confirm clinical observations they

[2] The investigation of germicides, Journ. Am. Med. Assoc. 91 No. 10 (September 8, 1928) 728.

are of value, and that whenever they do not they should be disregarded. This attitude seems to slight the value of laboratory investigations. Yet laboratory investigations have been and always will be the only procedure of gaining fundamental information as to new chemotherapeutic drugs. Whenever there is a disagreement between laboratory and clinical findings with regard to chemotherapeutics such disagreement can be explained by no other means than further laboratory investigation. There are many intances in the history of medical research where biologic laboratory investigations revealed information that revolutionized treatment in the clinic or revised and corrected the chemical conception of a drug. The structural formula of atoxyl was accepted and maintained until biologic investigation showed discrepancy between the trypanocidal effect of atoxyl and its structural formula. The formula of atoxyl was revised by further chemical investigation and corrected. This shows the value of biologic laboratory investigation in chemotherapy.

The editorial mentioned above appears to be a critical analysis of the methods employed in testing the comparative germicidal power of mercurochrome-220 soluble and iodine solution in skin disinfection. The editorial leads one to expect the results of such analysis for it says: "It may be well to examine *carefully* the methods used in an attempt to discover the reasons for these discrepancies and to establish the actual clinical value of the germicides in question." One experienced in laboratory investigation has to resort to the papers in question since the alleged discrepancies are, according to the editorial writer, due to differences in technic. There are certain discrepancies in the description of the methods used as given in the original papers and as they are presented in the editorial.

If we analyze the procedures of investigation as given in the publications with which the editorial is concerned we see that Reddish and Drake [3] were primarily interested in their test in the preoperative disinfection of skin. Therefore, staphylococcus, the most resistant of nonsporogenic bacteria, was used exclusively. The tests were restricted to one procedure with one kind of bacteria, the object evidently being to get comparative results of the two drugs concerned, and to obtain information of their relative value in disinfection of skin under usual conditions. In other words only one procedure was used. Simmons [4] on the

[3] Journ. Am. Med. Assoc. 91 No. 10 (September 8, 1928) 712.
[4] Journ. Am. Med. Assoc. 91 No. 10 (September 8, 1928) 704.

other hand included in his test not only staphylococcus, the commonest contaminant of skin likely to infect surgical wounds, but also other bacteria which, though not quite as common as staphylococcus in certain localities and under hospital conditions, are none the less very important; for example, he also included experiments with sporogenic bacteria that are common contaminants of skin around traumatic wounds, which occur on the battlefield and elsewhere. He furthermore performed inoculation experiments to see whether the virulence of the bacteria was impaired or not. Thus Simmons used four procedures while Reddish and Drake used only one of the four used by Simmons. Consequently only part of Simmons experiments are comparable with those of Reddish and Drake. The latter-mentioned authors inserted in their report of their own experiments the clinical opinion of others, thus apparently fulfilling the requirement of the editorial writer. This comment, however, seems to weaken rather than strengthen their argument in favor of mercurochrome and insinuates that their laboratory results were not strong enough to support their claim.

The first of the four procedures used by Simmons was a comparative test of tincture of iodine and mercurochrome in liquid media in which the bacteriostatic effect was checked. The second procedure was the comparative test on agar plates of these two drugs dried on pieces of gauze. The third procedure, which represents experiments on the skin of animals, was an approximation of the conditions existing in the actual use of this germicide in preoperative disinfection of skin. In the last procedure definite areas were contaminated with several kinds of bacteria that represented practically all the groups that enter into the problem of surgical wound infection. After about two hours the skin area was treated with the germicide in question and after definite intervals of time cultures were made on an agar plate and into a 100 cubic centimeter bouillon flask. This done, a second set consisting of agar plate and 100 cubic centimeter bouillon flask were inoculated by washings from a smaller area of the already washed skin. The third set, an agar plate was inoculated with scrapings from the center of the same treated area, therefore from a part of the skin that had been washed twice. The material inoculated was therefore diluted in 100 cubic centimeters of bouillon in Simmons's experiments and in 250 cubic centimeters in experiments of Rodriguez.[5] This is a

[5] Journ. Am. Med. Assoc. 91 No. 10 (September 8, 1928) 708.

far greater dilution than that in experiments of Reddish and Drake who suspended the material examined in 1 cubic centimeter of salt solution and 15 cubic centimeters of agar. Simmons, by successive washings of the treated skin, gradually diluted the germicide. The bacterial content of the surface, as well as of the deep layers of the skin, was investigated at the same time that the actual preoperative conditions were duplicated. Simmons used large amounts of bacteria and considered only striking differences in growth on the surface of plates and in the bouillon flasks. This part of Simmons's experiment is comparable with the experiments of Reddish and Drake, the difference being that Simmons used several kinds of pathogenic microörganisms while Reddish and Drake used only staphylococcus. In this part of the experiments the differences in technic are that Simmons used large amounts of cultures and inoculated plates on the surface, while Reddish and Drake attempted to use a more definite and smaller number of bacteria and poured plates and counted the colonies. This deviation by Reddish and Drake from the technic of Simmons creates at first sight the impresson of greater accuracy. The careful consideration of this procedure discloses that the estimated number of bacteria placed by Reddish and Drake on the area of contaminated skin gives no indication of the actual number of bacteria present on that area of skin at the time of application of the drug, because not only were the animals allowed to move freely in the cage but twenty-four hours expired between the contamination of the skin and the actual testing in some experiments, and the number of bacteria originally placed on the skin could in no way indicate the number of viable bacteria present twenty-four hours later. The counting of the colonies instead of estimating the gross differences of growth also creates an impression of greater accuracy in the work of Reddish and Drake. However, differences of a few colonies were considered as significant, and it was evidently taken for granted that each colony originated from a single bacterium. If one follows the growth of bacteria in hanging drop by Barber's single-cell isolation method one will easily see that the bacteria multiply at an even rate, even conditions being granted, and cling together until the chain or the cluster, as the case may be, of the bacteria reaches large dimensions. Then the groups of bacteria begin to break down into small groups. This, however, does not happen in each hanging drop at the same time. Each separated part of the chain or cluster will give rise to individual colonies. Con-

sequently the same number of bacteria, up to a certain limit, may give rise to 1, 2, 4, 6, or 8 colonies. This period of growth before the periodic breaking down of the large cluster or chains of growing bacteria is responsible for the lag observed when growing cultures are plated at short intervals of time and when the colonies are counted. The apparent refinement therefore of the methods as used in the experiments of Reddish and Drake may give rise to errors. The same can be said about their methods of checking the bacteriostatic action by planting, on the surface of the poured plate, a streak of staphylococcus culture to prove that the germicide in question has been reduced to noninhibiting dilution. When the investigated material is placed in 1 cubic centimeter of liquid on the bottom of the Petri dish, as was done by Reddish and Drake, and the cooled melted agar is poured on top of it, the distribution of the remnants of the germicide will not be even throughout the medium. A thorough shaking in a plate and consequently thorough mixing of the drug with the medium is not guaranteed by such a procedure, because the germicide was placed at the bottom of the plate. The surface of the agar plate is likely to have much less of the germicide than the material in any portion especially the bottom of the agar plate. Moreover, a good many chemicals may become absorbed by the culture medium in twenty-four hours. They may be bound physically to the material under investigation and exert bacteriostatic action on the tested material, but not on the rest of the medium. The solubility in water of the examined drug also comes into play.

It seems superfluous to attempt refining of only one or two out of a number of factors involved in testing a germicide and expect uniform and exact results. In the usual Hygienic Laboratory coefficient method all the important factors are controlled—temperature, the time of exposure, the dilutions, the reaction of the medium, the quantity of inoculum, an a well-known, constantly used culture. Let us neglect one of the factors in this standard method of testing general antiseptics and scrupulously observe the rest of them then surely we shall be disappointed in our expectation of uniform results. Furthermore, in counting deep colonies as done by Reddish and Drake it is difficult to eliminate accidental contamination of the plate, particularly when so common a contaminant of plates as staphylococcus is used. The fallacy of laying stress on differences of a few colonies is evident, because the supposition that one colony results from a single bacterium does not correspond to reality.

We come, therefore, to the conclusion that the experiments of Simmons on the one side and those of Reddish and Drake on the other vary in so much that Reddish and Drake declare the bactericidal action of mercurochrome to be equal to that of tincture of iodine and Simmons finds that tincture of iodine is superior to mercurochrome. Reddish and Drake's conclusion was drawn from their experiments with one type of bacteria. Simmons draws his conclusions and supports them by the results of experiments performed with six representative bacteria; namely, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Streptococcus scarlatinæ*, *Escherichia coli*, *Clostridium welchii*, and *Bacillus anthracis*. Simmons's contention of the superiority of tincture of iodine is further strengthened by his inoculation experiments which showed that tincture of iodine prevented the death from anthrax of experimental animals, mercurochrome failed to do so. The discrepancies between the conclusions drawn by Simmons and those of Reddish and Drake are due not so much to differences in the technic used as to the fact that Reddish and Drake limited their experiment to one kind of bacteria and to one method of investigation while Simmons attacked the problem from a much broader view. He considered more than one possibility of skin infection and attacked the problem from more than one angle. Hence the differences between the conclusions drawn by Simmons and those arrived at by Reddish and Drake. Which of the two gives more complete evaluation of the drugs in question must be clear to any competent reader.

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The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

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VOL. 40, NO. 3 NOVEMBER, 1929

THE PHILIPPINE JOURNAL OF SCIENCE

MANILA
BUREAU OF PRINTING
1929

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science, Department of Agriculture and Natural Resources
Government of the Philippine Islands

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THE PHILIPPINE
JOURNAL OF SCIENCE

Vol. 40 NOVEMBER, 1929 No. 3

NEW OR INTERESTING PHILIPPINE FERNS, VII[1]

By EDWIN BINGHAM COPELAND
Of the University of California, Berkeley

NINE PLATES

The ferns here described or discussed were collected on Mount Matutum, or attracted attention in connection with the determination of the ferns collected there, or in the preparation of a second century of the author's Pteridophyta Philippinensia Exsiccata. Mount Matutum is an extinct volcano standing above Sarangani Bay, in southeastern Mindanao. It is the farthest south of the high mountains of the Philippines. As was to be expected, its vegetation was found to be similar to that of Mount Apo. The two days spent in the ascent and return showed it to be one of the richest collecting grounds in the Archipelago.

In view of the apparently general opinion that the Philippine fern flora has been well studied, it is in order to note that a really large number of species already in herbaria are still undescribed.

OSMUNDA HERBACEA Copeland sp. nov.

Plenasium, stipite 70 cm alto, 1 cm crasso, basi invisa alibi glabro; fronde 1.5 m alta, sursum sterile; pinnis ca. 8 cm longis, 8 mm altis, cum stipitulis usque ad 8 mm longis, sterilibus grosse sed haud argute serratis, sinubus rotundatis, dentibus serrulatis, herbaceis, fertilibus pinnatis.

MINDANAO, Mount Matutum, *Copeland s. n.*, May 1, 1917.

A single fertile frond was found, and this suffered in the press, nearly all pinnæ separating from the rachis. Even with

[1] The sixth paper with this title appeared in Philip. Journ. Sci. § C 7 (1912) 53.

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the poor and scant material, the texture, the rounded sinuses, and the serrulate teeth distinguish it from the only other species otherwise like it, *O. banksiifolia.* Hooker, Exotic Ferns, 9, complained that the species of *Plenasium* were ill defined; but this seems to me to be true only of his own *O. vachelii,* which is at least very close to *O. javanica. Osmunda banksiifolia* and *O. bromeliaefolia* are as distinct as species need be.

Why is *O. cinnamomea* not known as *O. bipinnata* Linnæus—assuming that they are synonyms? The latter name has page priority. There is a rule—which is contrary to the principles underlying the whole body of rules—against any page priority, but such a rule is inapplicable to species, and in questions in which specific names alone are involved; no such thing as a *species conservanda* has ever been proposed. No present authority is recognized as competent to maintain a second specific name as against a first one, though the difference be only in position on the same page.

GLEICHENIA PELTOPHORA Copeland sp. nov. Plate 1.

Eugleichenia, rhizomate late repente, 1.5–2 mm crasso, lignoso, glabrescente; stipitibus remotis, usque ad 60 cm altis, castaneis, superne applanatis, inferne rotundatis, sparse punctulatis, glabris vel mox grabrescentibus: pseudo-pinnis oppositis, 1-vel pluriparibus, infimis rarius ut rami frondium compositis, plerumque definitis, usque ad 30 cm longis, anguste lanceolatis, abrupte caudatis, deorsum angustatis, rhachibus glabrescentibus superne late sulcatis; pinnulis infimis remotis et diminutis, medialibus permultis erecto-patentibus vulgo 4 cm longis, 2–3 cm latis, sessilibus, fere ad costam glabrescentem pinnatifidis; segmentis confertis, oblongo-semiorbicularibus, marginibus leviter deflexis, in vetustate cucullatis, coriaceis, superne nigro-fuscis, inferne glaucis et paleis magnis peltatis orbicularibus castaneis pallidius marginatis ornatis; soris solitariis, profunde immersis, sporangiis plerumque 4, flavis.

MINDANAO, Mount Matutum, altitude 1,600 meters, May 1, 1917.

Nearest to the South African *G. polypodioides;* among Malayan species, to *G. vulcanica,* which has more moderately immersed sori. It approaches *G. longissima* as described by Blume, but the conspicuous peltate scales distinguish it very clearly from all other species. These are commonly 5 to 8 to the segment, and occupy about half of its surface. This is a remarkably large plant, for an *Eugleichenia.*

CYATHEA LEYTENSIS Copeland.

Cyathea leytensis COPELAND, Philip. Journ. Sci. 38 (1929) 131.

MINDANAO, Mount Matutum, *Copeland P. P. E. 187.*

Previously known only by the type collection, from Leyte. The Matutum specimen is exactly like the type in its white-ciliate paleæ and pale tawny indusia. The secondary pinnules are nearly entire, as contrasted with those conspicuously crenate on the type, which may be correlated with the fact that the Matutum plant is much less copiously fruiting. The trunk is 5 cm in diameter, and very hard. The stipe bears very slender tawny paleæ at the base. It is everywhere densely furfuraceous, and black under the fuzz. Within 10 cm of the base are one or two dwarfed pinnæ, about 6 cm long. The next pinnæ, 30 cm long and fully developed, though shorter than those still higher up, are 40 cm removed from the little basal ones. It is still another 40 cm up to the real body of the frond. Thus the ample expanded crown of fronds has its main laminar development begin about a meter out from the center, but the small lower pinnæ make some use of the central area. The stipes and the lower part of the rachises are beset with very sharp spines, 2 to 3 mm long; whatever animals of any size might menace the foliage must be kept away effectively by this long spiny bar.

DRYOPTERIS GYMNOCARPA Copeland.

This species was described from small plants collected by Elmer on Mount Apo, Mindanao. From the Mountain Province, northern Luzon, have come specimens which seems to represent it; namely, an ample collection now distributed as *Pteridophyta Philippinensia Exiccata No. 160;* a single sheet, collected above Bagnen, in Lepanto, in 1905; and a sheet labeled *Athyrium macrocarpum, Philippine Plants No. 966,* collected in Benguet by Merrill. Their height runs up to 30 centimeters, with free pinnæ correspondingly more numerous than in *D. gymnocarpa* as described. They are much smaller and narrower than *D. africana.* The young sporangia of the Benguet specimens are freely setuliferous, as in *Dryopteris somai* Hayata, of Formosa.

DRYOPTERIS RIZALENSIS Christ.

The type of this species is from San Ramon, Zamboanga Province; the Rizal plant, although it provided the specific name, being "a smaller form," and thus, at least, not typical. The type was collected at 475 meters altitude, and I have specimens from 800, 1,000, and 1,050 meters. The indusium, described as "reniformi flaccido griseo mox evanido," is wonderfully beset with

short, thick, white trichomes, becoming tawny with age. These stand almost contiguous along the margin, and are far from sparse all over the outer surface. It is persistent, and becomes "evanido" only as it is crumpled together by the growth of the sporangia, so that in full fruit only some of the ciliate margin remains visible between them. The Mount Apo plant which has been cited as this species is aberrant, being larger and with less bristly axes.

Dryopteris preslii (Baker) O. K., known only by the type collection, *Cuming 255,* is very near to *D. rizalensis.* Christ seems not to have had this plant, and to have mistaken another fern for it, when he associated it with *"Phegopteris obscura."* As compared with *D. rizalensis,* it is more finely but less densely aciculate, the intermediate pinnæ are few and relatively broad, and the trichomes on the indusium are red, glandular, and clavate.

Another nearly related fern, also present at San Ramon, can be called *D. aciculata* (Baker) C. Chr. It is perfectly identical with specimens from Sarawak, but intermediate in stature and dissection between typical *D. aciculata* and *D. sarawakensis* (Baker) v. A. v. R. If these two are not separable, the latter is (as between the two) the valid name.

DRYOPTERIS GRACILIS Copeland sp. nov.

D. Beddomei affinis, stipitibus remotis et frondibus gracilioribus distincta; rhizomate latissime repente, 1–1.5 mm crasso, nigrescente, paleis sparsis appressis castaneis anguste ovatis 1–2 mm longis deciduis vestito, glabrescente; stipitibus inter se 1–5 cm remotis, basibus nigris decidue paleaceis, sursum stramineis glabris, 5–12 cm altis, gracillimis; fronde lineare, usque ad 30 cm longa et 3 cm lata, utrinque longissime attenuata, bipinnatifida, apice acuminata pinnatifida, pinnis usque ad 40-paribus, infimis remotis ad vestigia plerumque trifida 1–2 mm longa reductis, rhachi sparse albo-pilosa; pinnis medialibus horizontalibus, sessilibus, basibus dilatatis 5 mm latis, obtusis, profunde pinnatifidis, papyraceis, superne obscuris fere glabris, inferne ad costas venasque setis gracillimis 0.5–1 mm longis albis ornatis, sparse ciliatis; segmentis 1–1.5 mm latis, majoribus ad apices crenato-dentatis; venulis 2- vel 3-paribus, simplicibus; soris ad venulas inferiores subapicalibus; indusiis glabris, mox evanidis.

MINDANAO, Mount Apo, altitude 1,700 to 1,800 meters, *Elmer 11520* (type), *11592.*

Distributed as *D. beddomei* (Baker) O. K., a species common in the highlands of northern Luzon, and otherwise unknown in the Philippines. So far as explicit published descriptions go, *D. beddomei* would include this fern, but they are distinct enough in appearance. I have no specimens of it from India; but it was described by Beddome (Ferns of Southern India, p. 38) as having the fronds crowded. The fern of southern China, referred to by both Beddome and Baker, has them clustered, however long the nonfrondiferous portions of the rhizome may be, as is true also of all Benguet specimens.

DRYOPTERIS ELMERORUM Copeland sp. nov. Plate 2.

Nephrodium rhizomate breve, repente vel adscendente, valido; stipitibus caespitosis, 20–35 cm altis, basi 3 mm crassis paleis castaneis lanceolatis 3 mm longis ciliatis vestitis, sursum rhachibusque dense minute pubescentibus gracilescentibus; fronde 20–30 cm alta, 12 cm lata, pinnata, apice 10 cm longa pinnatifida valde acuminata; pinnis ca. 9-paribus, supremis adnatis, aliis stipitulatis stipitulis 1–2 mm longis, pleresque cordatis, infimis plus minus deflexis basi rotundatis, omnibus breviter acuminatis, versus apices serrulatis, alibi leviter (¼ ad costam) lobatis, lobis 3 mm latis, falcato-rotundatis, ob excisionem inter apices venularum dentatis, papyraceis, superne setuliferis, inferne ad costas setis parvis densis et majoribus paucis ornatis, ad venas venulasque sat dense setuliferis; venulis ca. 6-paribus, ca. 3-paribus anastomosantibus, inferne praestantibus, vena secundaria ad sinus excurrente ob laminam hic infraflexam praestantissima; soris supramedialibus, indusiis orbiculari-reniformibus bullatis minute pubescentibus persistentibus obtectis.

MINDANAO, San Ramon, altitude 1,000 meters, November, 1911.

This very distinct species is named in joint honor of the two botanists most responsible for our knowledge of the Philippine flora—Elmer D. Merrill, my companion when it was collected, and A. D. E. Elmer.

DRYOPTERIS PILOSIUSCULA (Zipp.) C. Chr.

LUZON, Tayabas Province, Infanta, *C. B. Robinson, Bu. Sci. 9455*, August, 1909.

Identical with specimens from Java, determined by Christensen. Hitherto known only from Java.

DRYOPTERIS XIPHIOIDES Christ.

Dryopteris xiphioides CHRIST, Philip. Journ. Sci. 2 § C (1907) 201.

This species was apparently described from a single specimen. It belongs in a group in which, if one be disposed to make fine

distinctions, there is no limit to the number of species. The type material has the most ample fronds, among all which I refer to this species; it is rather old and described as exindusiate. Better specimens show a vestigial indusium, without definite form. The sori are basal on the veinlets, commonly paired, and often confluent. The lateral pinnæ of most specimens are strongly auricled on the upper side, and more slender than on the type. As rare variants, the terminal leaflet may be pinnately lobed; and the lowest pair of pinnæ may be dilated above the base, suggesting *D. diversiloba.* Including all of these forms, we have an ill-definable species; but this is better than describing each plant as distinct. I have a number of specimens from Binalui, a few miles from the type locality, and a single one from Lanao, collected by Mrs. Clemens. It is related to *D. merrillii* Christ, which is perhaps too nearly related to *D. hosei.*

DRYOPTERIS TEPHROPHYLLA Copeland sp. nov.

Sp. D. spenceri similis et affinis, fronde minore et tenuiore, soris vix elongatis, indusio parvo inconspicuo distincta; rhizomate breve, repente vel suberecto, paleis castaneis ovatis lanceolatisve acuminatis usque ad 3 mm longis vestito; stipitibus stramineis, brevibus; fronde 30 cm, rarius usque ad 45 cm, alta, supra mediam 7–8 cm lata, utrinque sensim angustata et acuminata, rhachi pilis pallidis 1–1.5 mm longis sparsis ornata et brevissime dense pubescente, parte superiore ca. 10 cm longa pinnato-lobata, lobis ovatis subfalcatis apice rotundatis; pinnis sessilibus vel subsessilibus, maximis vix ultra 4 cm longis, 12–14 mm latis, subfalcatis, obtusis vel subacutis, basi truncatis vel bassiscopice cordatis, crenatis, sparsim ciliatis, tenuiter herbaceis, superne griseis pilis sparsis 1 mm longis ad venas ornatis, lamina decidue inconspicue pubescente, inferne pallide viridibus ad costas venasque pilis minoribus adspersis; pinnis inferioribus gradatim ad auriculas basales minutas triangulares reductis; venulis in pinnis majoribus saepius 2-paribus anastomosantibus, in apice pinnatifida plerumque areolas paucas irregulares more Haplodictyi efficientibus; soris medialibus, non vel vix elongatis; indusiis inconspicuis primo pilis paucis ornatis.

MINDANAO, San Ramon, altitude about 800 meters, type collected by E. B. C., April, 1905; collected again in the same vicinity in 1907 and 1911.

The type of this species is the specimen referred to by Christ, Philip. Journ. Sci. 2 § C (1907) 206, as distinguishable from *D. spenceri* "by its shorter and more numerous pinnae;" its original

label bears Christ's notations as "Nephrodium canescens (Bl.) var. nephrodiiformis Chr." and "N. Spenceri Copel. var." It is very distinct from the former, but so suggestive of an immature form of the latter that it is only as material of both has accumulated that I have become convinced of its stable distinctness. They differ constantly in size, texture, and color. The pinnæ of *D. spenceri* reach a size of 10 by 2.5 centimeters, and the larger ones are decidedly acuminate. Although the ampleness of lamina might be expected to carry with it greater complexity of venation, examination of many fronds has exposed only one or two of the supplementary areolæ, which are constantly present on well-grown fronds of *D. tephrophylla*. A remarkable feature of *D. spenceri*, as to which its diagnosis was singularly in error, is the form of sorus and indusium. These are not uniform, but are commonly elongate, sometimes more than twice as long as broad, and not uncommonly unequal-sided, of the typical *Athyrium* form. The indusium is persistent and strongly hispid.

DRYOPTERIS DIVERSILOBA Christ.

Dryopteris diversiloba (Presl) CHRIST, Philip. Journ. Sci. 2 § C (1907) 199, as "n. subsp.," and regardless of citation of specimens.
Nephrodium diversilobum PRESL, Epimeliae Bot. 47.

This species was described unmistakably by Presl, who cited *Cuming 51* and *102* as typifying and representing it. The same two numbers, and only these, are cited with the brief diagnosis of *Goniopteris asymmetrica* Fée. Cuming's numbers were notoriously mixed, but the evidence of the specimens is needed before it is easy to believe that two different ferns were both included under both numbers. As Fée evidently published his Genera Filicum before seeing Presl's Epimeliae, he might naturally have described the same fern independently; and my only reason for doubting that he did this is his expression, "segmentis in apice frondium inaequalibus," which does not apply to *D. diversiloba*, but does to a distinct, commoner Philippine species, otherwise perhaps nameless. Christ mistook the other species for *D. diversiloba* in publishing this combination; but he had previously indentified it for me using Fée's name, and must have returned to this view when he made the combination *Dryopteris asymmetrica*, Geographic der Farne, p. 226. His only mention of *Cuming 51*, the type collection of both *Nephrodium diversilobum* and *Goniopteris asymmetrica*, is in connection with his own *Dryopteris acromanes*.

These observations do not clarify this group, but they help to define the difficulties. The mixture under Cuming's numbers makes dependence on their citation impracticable, except as conformity of specimen and complete description insures indentity; as thus I know *Nephrodium diversilobum*. Whether or not the commoner species is *Goniopteris asymmetrica* can be known only after consultation of Fée's type. The moderns have added to the difficulty of selecting names in the group, by Christ's description of an indusium as wanting, and five lines later as peltate [Ann. Jard. Bot. Buit. **15** (1897) 131], and van Alderwerelt's resurrection of the specific name *blumei*. *Nephrodium blumei* J. Smith was a nomen nudum. A description was provided by Mettenius, as *Aspidium blumei*. The fern typifying it had already been endowed by van Alderwerelt with one useless new combination, as *Pleocnemia heterophylla*, Malayan Ferns, p. 171 (if there be a genus *Pleocnemia*, this is nothing like it), before he came to *Dryopteris blumei*, *ibid.*, p. 231. We can discard this name, positively. *Nephrodium subdimorphum* Christ may be a valid species; once published, the author seems to have forgotten it, for it is unmentioned in his Farnflora von Celebes and his Philippine Species of Dryopteris. I doubt the occurrence of *D. canescens* in the Philippines.

DRYOPTERIS DIMINUTA Copeland sp. nov.

"Meniscium" gregis D. canescentis; rhizomate repente, 1 mm crasso, paleis castaneis lanceolatis 2 mm longis vestito; stipitibus seriatis haud remotis, pubescentibus, 1–3 cm altis; fronde sterile 3–6 cm longa, pinnata, foliola apicale 2–4 cm longa, 1.5 cm lata, obtusa, lobata, herbacea, superne minute setosa, venis inferne setis persistentioribus majoribus donatis, venulis utroque latere venae 3 vel 4, quarum 1 vel 2 anastomosantibus; pinnis utroque latere ca. 2, stipitulatis, 3–8 mm longis, plus minus orbicularibus sed variabilibus, venulis interdum liberis; fronde fertile graciliore et longius stipitata, aliter conforme; soris elongatis interdum confluentibus, exindusiatis; sporangiis setiferis.

MINDANAO, San Ramon, altitude 1,200 meters, November, 1911.

This is probably a reduced, mossy-forest representative of the species provisionally called *Dryopteris asymmetrica;* it is not equally near to the known species with large apical leaflets—*D. simplicifolia, D. simplex, D. bakeri,* and *Haplodictyum heterophyllum.*

Near to this species, but aparently not identical, are *Elmer 10784* from Mount Apo, distributed as *D. canescens* var. *subsimplicifolia*, and *Merrill 6959*, from Canlaon Volcano, Negros.

Both are larger ferns, firmer in texture, with less setose veins, and the sporangia apparently naked; and the Canlaon plant has the pinnæ more conspicuously and uniformly contracted.

DRYOPTERIS MATUTUMENSIS Copeland sp. nov. Plate 3.

Rhizomate repente, 2–3 mm crasso, paleis parvis integris ovalis castaneis sparsis vestito; stipitibus confertis, usque ad 20 cm altis (plerumque multo brevioribus), paleis castaneis lanceolato-ovatis 2 mm longis sparsis et caducis, pilis minutis pallidis plerisque etiam deciduis, et pinnis paucis fronde (lamina) valde remotis ad auriculas abrupte reductis ornatis; fronde quam stipite longiore, vulgo 15–20 cm alta, 2.5—3 cm lata, sursum longe attenuata, in caudam integram desinente, parte superiore plerumque ultramedia pinnatifida, segmentis eiae partis contiguis, ca. 4 mm latis, obtusis vel oblique acutis, venis simplicibus; pinnis supremis paucis adnatis; inframedialibus liberis sessilibus, oblongis, apice rotundatis, crenatis vel inferioribus paucis inciso-lobatis, superne atroviridibus pilis minutis adspersis, inferne costa excepta glabris vel lamina punctulis ochroleucis minutis adspersa, papyraceis; venis pinnarum furcatis pinnatisve, venulis infimis rarissime anastomosantibus; pinnis infimis (auriculis exceptis) paullo diminutis, deflexis; rhachi pilis pallidis inflexis vestita; soris medialibus, regulariter ordinatis, indusiis orbiculari-reniformibus, parvis, fuscis, glabris.

MINDANAO, Mount Matutum, altitude 2,000 meters, *E. B. and H. F. Copeland*, May 1, 1917.

In aspect this fern is remarkably like that known to me as *D. philippina* (Presl) C. Chr., but is distinguished by having the full upper half of the frond, instead of a short apical portion, pinnatifid, in distinction to pinnate, and by the presence of the little auricles on the stipe. One may not be too certain of the real nature of Presl's *Physematium philippinum* without seeing Presl's type, *Cuming 251 partim.* This number is represented in several herbaria by exactly the fern described and figured by Fée as *Phegopteris nervosa,* and described by Hooker as *Nephrodium (Lastrea?) exiguum.* From recent cellections, I have this species from Los Baños, which may have been a type locality (though Hooker cites "S. Ilocos" for this number), and from northeastern Mindanao—*Bolster 327, Merrill 7328, Elmer 14026.* Presl described his plant as having sessile pinnæ. Mettenius (Phegopteris und Aspidium no. 180) keyed it out that way, but described them as "brevissime petiolata." Actually, they are short-stalked in the lower part of well-grown fronds, but sessile on small fronds. Presl carefully described them as more cut

on the acroscopic than on the basiscopic side, which is characteristic of all specimens I construe as his species, but not of *D. matutumensis.*

Dryopteris matutumensis is much closer, and possibly too close, to another fern of northeastern Mindanao, *D. urdanetensis* Copeland. This was described as having hirsute indusia; but the hairs on them are so very few, at least now, after sixteen years in the herbarium, that they would be overlooked if the description did not demand careful search. It is, however, distinguished from *D. matutumensis* by being decidedly slenderer throughout, with more densely and more persistently pubescent stipes, and fewer, less remote, and less extremely reduced basal pinnæ. The widest of some twenty fronds in hand are 17 millimeters.

DRYOPTERIS CANLAONENSIS Copeland sp. nov.

D. matutumensi affinis et similis, rhachi setis inflexis saturate purpureis dense vestita, venis segmentorum partis superioris frondis infimis et ramulis inferioribus venarum pinnarum anastomosantibus, pinnis paullo majoribus et profundius incisis, et indusiis nullis vel caducis distincta.

NEGROS, Mount Canlaon, *E. D. Merrill 6934,* April, 1910.

Like the preceding species in general aspect, and in the dissection of the frond, pinnate in the lower and pinnatifid in the upper half, and in the auricles on the stipe. Stipe about 15 centimeters tall; frond slightly longer, 4 centimeters wide, subcoriaceous in texture, dark green above and olive beneath, upper surface naked except for the appressed-pubescent costæ, beneath sparsely setose on the axes and the lamina bearing sparse minute globules; in the largest fronds, sori are borne on other, as well as on the lowest, veinlets, and these cease to be in regular rows. The historic attempts to break up this great genus, whether the resulting groups are characterized by the characters of the indusium or of the venation, would have separated these two species very widely; and yet, they could hardly be more nearly related and be separable specifically.

DRYOPTERIS AUSTRO-PHILIPPINA Copeland sp. nov.

Praecedentibus (D. urdanetensi, D. matutumensi, et D. canlaonesi) affinis; rhizomate repente, paleis castaneis 1 mm longis vestito; stipitibus dense confertis, fusco-stramineis, ad basin decidue paleaceis, alibi minute nec dense pubescentibus, vix 10 cm altis, sursum auriculis 1- vel 2-paribus 0.5–1.5 mm longis ornatis; rhachi pallide setosa; fronde 12–15 cm longa, 3 cm lata, valde

acuminata, parte supramediale pinnatifida, inframediale pinnata; segmentis partis pinnatifidae oblongis, apice rotundatis, integris, venis simplicibus infimis 1-paribus anastomosantibus, soris medialibus; pinnis sessilibus, oblongis, basi truncatis, apice rotundatis, lateribus inciso-crenatis, lobis 1.5 mm latis rotundatis' herbaceis, superne inconspicue et sparse setuliferis, inferne sparse globuliferis, pinnis infimis deflexis plerumque brevioribus; venulis plerumque 2-paribus, infimis anastomosantibus, rarius 3-paribus et medialibus in sinus conniventibus, venulis frondium fertilium omnibus plerumque soriferis, soris inframedialibus vel costularibus, multis, laminam totam deinde plus minus complentibus, indusiis nullis vel caducis.

MINDANAO, San Ramon, altitude 800 meters, *Copeland 1705* (type). Collected at the same place in 1907 and 1911; also at Camp Keithley, *Mrs. Clemens s. n.*, October, 1907. *Elmer 10204*, from the Horn of Negros, formerly determined by me as *D. canescens* var. *lobata* Christ, is probably a large form of this species, with stipes 20 centimeters tall. This plant (the type collection) was cited by Christ, Philip. Journ. Sci. 2 § C (1907) 202, as *D. philippinensis;* but it is distinct from that species in having auricles on the stipe and the upper half of the frond pinnatifid. In both of these respects it is like the preceding species. In breadth of frond and in depth of cutting of the pinnæ, it is like *D. canlaonensis;* also, its indusia are at best ephemeral, and the lowest veinlets anastomose more often than not; but the hairs on its rachis are pale, the texture is decidedly thinner, there are at most two pairs of auricles, and the upper surface of the lamina bears minute setæ, at least when young.

ATHYRIUM GYMNOCARPUM Copeland sp. nov. Plate 4.

Caudice erecto, 5 cm crasso, eodem et basibus multis applanatis stipitum truncum brevem validum efficentibus; stipitibus fasciculatis, plus minus carnosis, usque ad 25 cm altis, ad pedes negros dilatatos paleis castaneis ovatis lanceolatisve dense vestitis, sursum paleis lanceolatis pallidioribus sparsis ornatis; fronde ca. 30 cm alta, 15 cm lata, acuminata, profunde bipinnatifida, apice pinnatifida; pinnis patentibus, oppositis, subsessilibus vel supremis adnatis, infimis vex vel paullo diminutis haud deflexis, medialibus ca. 10 cm longis, acuminatis apice serratis, basitruncatis, tenuiter membranaceis, glabris, fere ad costam pinnatifidis; lobis oblongis, maximis 11 mm longis, 6 cm latis, contiguis vel infimis subremotis ala connexis, apice aequalateraliter rotundatis, obscure crenatis vel obtuse denticulatis; venulis fere

omnibus furcatis; soris subcostalaribus, elongatis, aut simplicibus, aut ad ramos ambos venularum protensis et ideo V- vel rarius Y-formibus, haud indusiatis.

MINDANAO, Mount Matutum, altitude about 1,200 meters, *E. B. and H. F. Copeland*, April 30, 1917.

Intermediate between *A. opacum* (Don) Copeland, which is bipinnate, with the basal pinnæ largest, and *A. gillespiei* Copeland, of Fiji, which has simple veinlets, and the basal pinnæ reduced and deflexed.

ATHYRIUM OREOPTERIS Copeland sp. nov. Plate 5.

Rhizomate adscendente, vero 3–5 mm crasso, basibus incrassatis stipitum caespitosorum occulto; stipitibus usque ad 30 cm altis, basibus nigris paleis laete brunneis linearibus 5 mm longis vestitis, sursum stramineis, gracilibus, glabris; fronde ca. 30 cm longa, acuminata, subbinpinnata, apice angusta pinnatifida, papyracea, glabra, inferne olivacea, rhachi nuda, facie ventrale exsculpta; pinnis subsessilibus, usque ad 8 cm longis sed plerumque brevioribus, lanceolatis, diversissime arcuatis vel rarius fere rectis et horizontalibus, valde (usque ad 5 cm inter se) remotis, infimis solummodo oppositis plerumque paullo abbreviatis, obtusis vel acutis, ad alam angustam decurrentem pinnatifidis; segmentis oblongis, apice rotundatis, basi obliquis adnatis vel majoribus acroscopice subliberis, infimis solummodo interdum liberis (et ita in pinnulas transeuntibus), minoribus argute dentatis, majoribus leviter inciso-lobatis, lobis plerisque bidentatis; venulis inferne conspicuis, nigris; soris brevibus, plerisque asplenioideis, inferioribus curvatis, indusio brunneo bullato.

LUZON, Mountain Province, Mount Pulog, altitude 2,900 meters, under rocks of open summit, *Copeland 2305*, May 13, 1909.

Faurie 566, from Mount Ari, in Formosa, altitude 2,500 meters, differs only in being larger. In that to this extent it does not fit the diagnosis based on the Luzon specimens, it may be a variety *majus.* As a Luzon plant, this is one of the northern immigrants, its affinities being only to species of farther north—as to *A. niponicum* and *A. regiscens.*

ATHYRIUM TENUIFOLIUM Copeland sp. nov.

Caudice erecto; stipite 30–50 cm alto, usque ad 5 mm crasso, basi paleis castaneis 1 cm longis anguste lanceolatis integris vestito, sursum glabrescente, ob relicta basalia palearum caducarum sparse muriculato, rhachibusque fuscis; fronde 1 m longa, subtripinnata; pinnis suprabasalibus maximis, 30–35 cm longis, 15 cm latis, alternantibus, stipitulis 1.5–2 cm longis praeditis,

acuminatis; pinnulis majoribus 8 cm longis, 25 mm latis, pedicellatis, basi cordato-truncatis, caudato-acuminatis, apice serratis, basin versus fere pinnatis, glabris, tenuiter papyraceis, atroviridibus; segmentis oblongis, obtusis, usque ad 15 mm longis, infimis 6 mm latis incisis, sequentibus 5 mm latis argute serratis; venis plerisque furcatis; soris costularibus, brevibus, plerisque ca. 1 mm (rarius usque ad 1.5 mm) longis, plerisque diplazioideis, indusio obscuro, integro.

MINDANAO, San Ramon, altitude 800 meters, *Copeland P. P. E. 198, Copeland 1493a;* Mount Apo, *Copeland 1493.*

This fern was included in *Arthyrium silvaticum* (Blume) Milde in my revision of the Philippine species of the genus, Philip. Journ. Sci. 3 § C (1908) 293, and possibly correctly. It is not *Brachysorus woodwardioides* Presl, *Athyrium basilare* Fée, a Luzon fern, distributed as *P. P. E. 82.* Its axes and palæ are not so dark, the lamina is darker, the stipe is decidedly rough, and the segments are more ample and more sharply serrate. I have no Java specimen of *Athyrium silvaticum,* which was described as with the pinnules "ad costam subtus sparsim paleaceis;" which van Alderwerelt, Malayan Ferns, p. 829, amended to "rachis and surfaces naked." The latter author says that the indusium is "ciliate or eroso-fimbriate." The most similar fern I have from Java, which I suppose to be **Athyrium muricatum** (Mettenius) Copeland comb. nov.—*Asplenium muricatum* Mettenius, Ann. Mus. Bot. Lugd.-Bat. 2 (1866) 239—has a remarkably stout and naked creeping rhizome.

ATHYRIUM CALLIPHYLLUM Copeland sp. nov. Plate 6.

Rhizomate valido, repente vel adscendente; stipitibus caespitosis, 30–35 cm altis, sulcatis, deorsum 1 cm crassis, obscuris, obique paleis castaneo-nigris angustissimis deorsum 1 cm longis plus minus rectis sursum minoribus crinitis marginibus setis minutis patentibus ornatis dense et persistente vestitis; fronde ca. 75 cm alta, ovata, profunde tripinnatifida, rhachibus setoso-paleatis, paleis in proportione crassitiei axium gradatim diminutis et remotis; pinnis infimis 20–25 cm, sequentibus fere 30 cm longis, 10 cm latis (rarius latioribus), brevi-pedicellatis, acuminatis; pinnulis infimis paullo reductis, inframedialibus maximis, 5.5–6 cm longis, 2 cm latis, acutis, brevissime pedicellatis, basi truncatis vel subcordatis, ad alam angustam coste inferne deorsum squamulosae pinnatifidis; segmentis 1 cm longis, 3–4 mm latis, spatio angustiore remotis, ala vix 0.5 mm lata connexis, obtusis, glabris, herbaceis, maximis medio ad costulas oblique

incisis, minoribus serratis; venis in lobis segmentorum majorum pinnatis, ramis utroque latere 1 vel 2; soris solitariis, simplicibus vel infimo acroscopico segmenti interdum bilaterale, e costula fere ad marginem protensis; indusio castaneo, persistente.

MINDANAO, Mount Matutum, altitude 1,800 meters, *E. B. and H. F. Copeland*, May 1, 1917.

A very distinct species, combining the foliar aspect of the group of *A. umbrosum* with axes clothed as in *A. vestitum.*

ASPLENIUM ELMERI Christ.

MINDANAO, Mount Matutum, altitude 1,800 meters, *E. B. and and H. F. Copeland,* May 1, 1917.

A common fern in Benguet. In the publication of this species, Christ mentioned a similar plant from Celebes. The Matutum specimens are typical, and, as is usual in Benguet, are bipinnate if the fronds are small, tripinnate if they are large.

LINDSAYA GRACILIS Blume (?).

MINDANAO, Mount Matutum, on *Cyathea* trunks, altitude 2,100 meters, *E. B. and H. F. Copeland,* May 1, 1917.

Lindsaya gracilis has been acredited to the Philippines in the past, but every collection known to me as responsible for such reports is the very distinct, terrestrial *L. concinna,* with clustered fronds. The Matutum specimens have tortuous, filiform, scandent rhizomes, filiform stipes 1 to 1.5 centimeters long, fronds about 10 centimeters by 8 millimeters, and pinnæ about 5 by 2.5 millimeters, most of them very shallowly 2–lobed. They conform perfectly to Blume's brief diagnosis, and reasonably well to Raciborski's more complete description. My lack of confidence in the identification is because the only specimen I have received with this name from Java is a larger and coarser fern, which I should rather call *L. adiantoides.*

CONIOGRAMME SUBCORDATA Copeland.

MINDANAO, Mount Matutum, altitude 1,950 meters, *H. F. and E. B. Copeland,* May 1, 1917.

The collection consists of a single frond, with stout, slightly scaly stipe 60 centimeters tall; lowest pinnæ 35 centimeters long; their lateral pinnules seven on a side, alternate, stalked, about 8 centimeters long, narrowed from a base about 16 millimeters wide to the very sharp tip. The pinnules of the type collection are fewer and much larger. The terminal pinnules of the Matutum plant are very long and slender. *Coniogramme squamulata* Hieronimus represents different individuals; or, perhaps, only a different individual.

MICROLEPIA TODAYENSIS Christ.

Microlepia hispidula v. A. v. R., Malayan Ferns Suppl. (1917) 233.

Copeland 1480 and *Elmer 10472*, the respective types of *M. todayensis* and *M. hispidula*, came from the same place. In reporting Elmer's collection, I held them distinct, and construed Elmer's plant as *Davallia villosa* Don. Van Alderwerelt corrected my error as to that species. With more material now in hand, I am unable to maintain any distinction between the two supposed Mindanao species. *Microlepia todayensis* is being distributed, from the base of Mount Matutum, as No. 186 of my Pteridophyta Philippinensia Exsiccata.

MICROLEPIA DONIANA Copeland nom. nov.

Davallia villosa DON, Prodromus Fl. Nepal. (1825) 10, not *Microlepia villosa* Presl.

Microlepia hirta of many authors, not of Presl.

This fern of India and Ceylon was not properly known by me when I construed one from the Philippines as identical with it. *Microlepia hirta* (Kaulfuss) Presl is known from Hawaii only.

MICROLEPIA TRAPEZIFORMIS (Roxb.) Kuhn.

A high-mountain species of northern Luzon, formerly distributed as *M. rhomboidea* (Wall.) Presl, represented by *Copeland 1891* and *Curran, Forestry Bureau 1892*, is doubtfully construed as *M. trapeziformis*. The fronds are thinly papyraceous, subtripinnate, with all axes persistently dark-hirsute, and with very hairy indusia.

PTERIS QUINQUEPARTITA Copeland sp. nov.

Species magnifica, adspectu P. tripartitae, P. radicanti affinis, apicibus non radicantibus, pinnulis multo numerosioribus et indusiis latis distincta; cuadice, teste Elmer, crassissimo, suberecto; stipitibus caespitosis, usque ad 140 cm altis, gracilibus, fusco-stramineis, ad pedes paleis paucis minutis linearibus adspersis, alibi rhachibusque validioribus mox glabrescentibus; fronde e foliolis radiatis V (rarius III) composita, quarum mediale fere 1 m longa, lateralibus late divergentibus paullo minoribus, omnibus subbipinnatis et quaque in pinnulam pinnulis lateralibus similem desinente; pinnulis sessilibus, caudato-acuminatis, usque ad 14 cm longis, 2 cm latis, pectinato-subpinnatis, costis squamulosis superne late sulcatis; segmentis contiguis et angustissime confluentibus, erecto-patentibus, apice rotundatis, intergris vel obscure crenulatis, sterilibus 3–4 mm latis, glabris, herbaceis; venis remotis, conspicuis, plerisque furcatis;

soris saepe brevibus et ad partes mediales segmentorum restrictis, nec non in fructificatione perfecta marginem fere totam occupantibus.

MINDANAO, Mount Apo, altitude 1,400 meters, *Elmer 11863* (type), *DeVore and Hoover 320, Copeland s. n.* (altitude 1,800 meters), *Williams 2456;* Mount Matutum, altitude 1,800 meters, *H. F. and E. B. Copeland.*

I have made Elmer's the type collection because it was distributed to many herbaria; but my specimen of it is the only one of the species in my possession with 3, instead of 5, primary divisions of the frond. It is cited by van Alderwerelt as *P. radicans* var. *javanica.* I have not used this varietal name as specific, because its corresponding type must be a Javan fern which I have not seen, and do not know to be identical with those from Mindanao. My field notes, made in 1903, show this fern as common in the Mount Apo rain forest, above 1,200 meters altitude. The pinnules are about 25 pairs on the middle segment, 20 on the intermediate, and 15 on the lowest, the segments radiating from a common point. *Pteris radicans* is described as having an even larger frond, but with only about half as many pinnules, and these only about 5 centimeters long, making up a frond of extremely different aspect.

HYMENOLEPIS CALLIFOLIA Christ.

MINDANAO, Mount Matutum, *Copeland P. P. E. 199.*

Previously reported only from Dutch Borneo. The Matutum specimens are thinner, longer-stalked (up to 15 centimeters), and narrower (not over 4 centimeters wide) than as described: but they are far more like the plant described by Christ than like either *H. spicata* or *H. platyrhynchos,* between which they are in some respects intermediate. The sterile segment reaches a length of 70 centimeters, the fertile 25 centimeters. The published description of the fertile segment, as vermiform, shows that it was either quite old or very dry when pressed. The rhizome is distinctive, creeping, stout, and conspicuously clothed with large, toothed, shinning, lead-colored paleæ.

To this species should probably be referred my var. *glauca* of *H. platyrhynchos,* described from Mount Apo, the fronds of which are now, after twenty years in the herbarium, brownish green, is described by Christ—no longer a glaucous blue as when fresh. The sterile segments of my specimen are short, but those of Matutum specimens are very variable. Here, too, probably belongs *Elmer 13818,* from Agusan Province, Mindanao,

conforming to Christ's description except that the greatest width of frond is only 38 millimeters, and the greatest length of spike only 10.5 centimeters.

CYCLOPHORUS LANUGINOSUS (Gies.) C. Chr.

Not uncommon in central and southern Luzon; found on Mount Matutum, in southern Mindanao, *E. B. and H. F. Copeland,* April 30, 1917; quite identical with Luzon specimens.

ELAPHOGLOSSUM ANGULATUM (Blume) Moore.

MINDANAO, Mount Matutum, altitude 1,600 meters, *E. B. and H. F. Copeland,* May 1, 1917.

Described from Java. The Matutum plant conforms to Blume's description and plate more perfectly than does McGregor's, from Benguet, given this name by van Alderwerelt, Bull. Jard. Bot. Buit., II **16** (1914) 14. The scales at the base of the stipe are appendaged exactly as figured by Blume, but those on the rhizome are almost entire when young. The paleæ of McGregor's plant are darker, longer, and more pointed.

CAMPIUM MEMBRANACEUM Copeland sp. nov. Plate 7.

C. hiteroclito affine; rhizomate 5 mm crasso, paleis castaneis lanceolato-ovatis 1.5 mm longis dense obtecto; stipitibus approximatis, frodium sterilium ca. 15 cm longis, pedes versus paleis angustis vestitis, alibi rhachique angustissime alata gracile glabrescentibus; fronde 30–35 cm longa, oblonga, pinnata deorsum subbipinnata, foliola apicale medialibus simile, oblongo-lanceolata, acuminata non flagellifera, interdum ad apicem gemmulifera, integra vel apicem versus serrulata; pinnis lateralibus plerumque 5- vel 6-paribus, medialibus ca. 10 cm longis, 2.5 cm latis, stipitulatis, integris, glabris, membranaceis, venatione laxa more C. heterocliti reticulata; pinnis infimis basiscopice auctis, plerumque cum pinnula una basiscopica et lobis confluentibus utroque latere 1 vel 2; fronde fertile conforme sed minore, pinnis 5 cm longis, 8 mm latis.

MINDANAO, Mount Matutum, *Copeland s. n.,* May, 1917.

CAMPIUM ENORME Copeland sp. nov. Plate 8.

C. gregis C. quoyani, rhizomate repente, sicco et corrugato 8 mm crasso, apicem versus paleis integris ovatis, sordide fuscis 2 mm longis deciduis vestito; stipitibus, inter se ca. 3 cm remotis, validis, erectis, frondium sterilium ca. 50 cm altis, deorsum paleis fuscis squarroso-acuminatis 3–4 mm longis et sursum similibus minoribus minus persistentibus ornatis, bisulcatis; fronde sterile

90 cm alta, pinnata apice parva pinnatifida gemmifera, pinnis grope apicem frondis gradatim reductis adnatis; pinnis liberis 20–28 paribus, infimis spatio 10 cm remotis, pedicellatis, quam sequentibus paullo minoribus; medialibus usque ad 18 cm longis, vix 3 cm latis, acuminatis, brevi-pedicellatis, basi basiscopice truncatis vel cordulato-truncatis, acroscopice latius cuneato-truncatis, ca. 1/3 ad costam oblique incisis, lobis obtusis spinescenti-denticulatis, sinubus acutis, plerisque spines occultis, herbaceis, nigro-viridibus; areolis inter costam et sinus ca. 3, inter venas primarias vulgo 5-seriatis, venulis liberis inclusis fere carentibus; fronde fertile longius stipitatis, fronde propria minore, pinnis ca. 9 cm longis, 9 mm latis, late crenatis vel subintegris inferne ubique sporangiiferis.

MINDANAO, Mount Matutum, May 1, 1917.

In fruiting condition, this is fully twice the size of common *C. quoyanum*. The other differences—such as the presence of four or five areolæ instead of two or three between adjacent main veins—are presumably correlated with the stature.

LOMAGRAMMA SUBCORIACEA Copeland ut sp. nov.

Lomagramma pteroides J. Smith var. *subcoriacea* COPELAND, Philip. Journ. Sci. 8 § C. (1908) 32.

I have now ample and thoroughly mature material of this plant, collected on Mount Matutum, and am satisfied that, as was suggested when it was described as a variety, it will better be regarded as specifically distinct. The peculiarities of firm texture, reddish color, and salient veins are constant, as are also the cordate-truncate bases of the sterile pinnæ. The fertile pinnæ are either obtusely hastate-lobed, or auriculate at the base. The sterile fronds may reach a length of a meter; the fertile are not quite so large. The rachis is densely and rather persistently scaly; the lamina minutely and less persistently so.

POLYPODIUM SPONGIOSUM Copeland sp. nov. Plate 9.

P. negrosensi affine; rhizomate breve, pilis fuscis ovato-lanceolatis minusquam 1 mm longis minute pallide ciliatis vestito, basibus radicum et stipitum exarticulatorum obtecto; stipitibus 5–10 mm longis, pilis vinicoloribus 1 mm longis horizontalibus dense vestitis; fronde lineare pendente, maxima visa 16 cm longa, 18 mm lata, obtusa, deorsum gradatim angustata, ad alam rhacheos pinnatifida; rhachi immersa, setosa, alis inclusis ca. 3 mm lata; segmentis apud rhachin 4–5 mm latis, ibidem subcontiguis et obliquis (acroscopice dilatatis), deinde usque ad apices rotundatas angustatis, integris, carnois (in siccitate col-

lapsis), minute purpureo-ciliatis et alibi sparsius pilosulis; costulis sinuatis; venis simplicibus vel infima acroscopica rarius furcata, immersis, ad marginem haud appropinquantibus; soris paucis, apices prope segmentorum, inter costulam et marginem medialibus, pilis densioribus cricumdatis, vix vel haud immersis. A P. negrosense, frondibus minus abrupte angustatis, segmentis remotioribus acroscopice dilatatis, et soris praestantius superficialibus distinctum.

MINDANAO, San Ramon, *Copeland s. n.* 1920, altitude 1,200 meters. Epiphytic on mossy trunks.

Distinguished from *P. khasayanum* and *P. barathrophyllum* by more spongy texture, hairier stipes, superficial sori, and the segments dilated on the upper side at the base.

POLYPODIUM MILLEFOLIUM Blume.

MINDANAO, Mount Matutum, altitude 2,100 meters.

Already known from Mount Malindang in Mindanao and Mount Kinabalu in Borneo, as well as from Java and Sumatra. The citation in Christensen's Index, Flora Javae Plate 78 A, agrees with Blume's text, p. 190; however, it should be Plate 88 B.

POLYPODIUM SUMATRANUM Baker.

MINDANAO, Mount Matutum, altitude 1,950 meters.

Already known from Mount Apo (as *P. pleiosoroides* Copeland), from Mount Kinabalu, and from Java and Sumatra.

Polypodium serraeforme Brause (not of J. Smith) is probably a small form of this species, our specimen of *Schlechter 18142* being altogether like some of the smaller ones from Matutum. The receptacles are mostly elongate (though the sori appear round), and superficial. The larger Matutum specimens have laminæ nearly 25 centimeters long, on stipes up to 6 centimeters long. The margin varies, from entire, through broadly crenate, to irregularly lobed.

POLYPODIUM BULBOTRICHUM Copeland sp. nov.

Grammitis, rhizomatis, brevi-repente vel suberecto, paleis ferrugineis ovatis obtusis vel apiculatis 1.5–2 mm longis vestito; stipitibus subfasciculatis, non vel vestigialiter articulatis, usque ad 6 (plerisque 3–4) cm longis, gracilibus, pilis castaneis debilibus et fragilibus usque ad 2 mm longis basibus plerumque inflatis interdum praestantim mammiformibus obsitis, deinde, pilis abrasis, plus minus horridulis; fronde lineare, usque ad 16 (plerumque ca. 10) cm longa, utrinque angustata, in herbario fusca et subcoriacea, sparse castaneo-setosa, nisi prope soros

glabrescente, decidue ciliata, in parte superiore cum pilis aliquot secus marginem sursumplexis, costa nigrescente; venis inconspicuis, saepe bis furcatis; soris subcostalibus, ad venulas infimas acroscopicas, setis protectis, receptaculo paullo elongato.

LUZON, Mountain Province, Mount Pulog, altitude 2,650 meters, *Copeland P. P. E. 136* (type), epiphytic in mossy forest, May 12, 1909, *Merrill 6376;* Pauai, altitude 2,100 meters, *Copeland 1949,* November, 1905; Mount Bulusan, altitude 2,650 meters *Copeland s. n.,* May, 1913.

This species has been distributed as *P. congenerum* and *P. caespitosum,* from both of which it is distinguished by the long hairs on the stipe, their stipes being densely short-pubescent. From these and other species it is usually easily distinguished by the swollen bases of the hairs on the stipe, and the hairs appressed to the margin of the upper part of the frond. Both of these features are variable; the appressed hairs are sometimes few, and may be lost; and the swollen bases, usually very conspicuous, are hardly evident on some stipes. *Polypodium fasciculatum* has long, weak hairs on the stipe, but they are pale; and its paleæ are narrow.

POLYPODIUM HEANOPHYLLUM Copeland sp. nov.

Grammitis, P. setigero affinis eodemque quondam confusa, paleis parvis occultis, frondibus tenuioribus, stipitibus densius hirsutis, laminis minus setigeris distincta, epiphytica; rhizomate ubique radicibus basibusque hirsutissimis stipitum profunde occulto, paleis brunneis 1–2 mm longis vestito; stipitibus percaespitosis, 2–8 cm longis, gracilibus, pilis castaneis horizontalibus 2–4 mm longis dense hirsutis; fronde pendente, usque ad 35 cm longa et 17 mm lata lateribus parallelibus, obtusa, basi acuta, pilis 2–3 mm longis ciliata, faciebus sparsim pilosis, fusca, siccatate membranacea; venatione luce reflecta occulta, luce permissa praestante, venis plerisque 2– vel 3–furcatis, venulis late divergentibus deinde curvatis et marginem versus currentibus; soris ad venulas infimas acroscopicas basalibus, subcostalibus, sporangiis setuliferis.

MINDANAO, Mount Matutum, altitude 2,000 meters, *Copeland, P. P. E. 158* (type); Mount Apo, *Copeland 1521, Elmer 11440,* distributed as *P. setigerum.*

This species is common at about 1,800 meters altitude on Mount Apo, where it has been collected repeatedly, and easily confused with *P. setigerum.* With ample material of both, of

my own collection and in hand together, the thinness of the Mindanao plant is at once conspicuous. With comparison invited by this difference, that of the paleæ is still more striking. These are 4 to 5 millimeters long on *P. sentigerum*, and very conspicuous, while on *P. heanophyllum* they are less than half as large, and visible at all only after the removal of a mass of stipe-bases. The sori are less strictly costal, and the difference in hairiness has already been noted. In texture and paleæ, *P. heanophyllum* differs alike from *P. setigerum* and *P. hookeri*. In both *P. setigerum* and *P. heanophyllum*, there is an occasional irregular anastomosis of the veinlets.

PROSAPTIA URCEOLARE (Hayata) Copeland comb. nov.

Polypodium urceolare HAYATA, Icones Plant. Formosanarum 5 (1915) 324.

Caudice suberecto, paleis fusco-griseis castaneo-ciliatis 4–7 mm longis e basi 1 mm lata usque ad apicem sensim angustatis vestito; stipitubus caespitosis, vestigialiter ad rhizoma articulatis, ca. 2 cm longis, pilosis, pilis 1.5 mm longis atrocastaneis; fronde usque ad 23 cm longa, lineare vel lineari-lanceolata, utrinque sensim angustata, basi in alam brevem et angustatam ad stipitem decurrentem descrescenta, fere ad costam pinnatifida, coriacea, ubique sed haud dense (inferne brevius) pilosa; costa valida sed immersa; segmentis modo remotis, majoribus ca. 1 cm longis et 4 mm latis, obtusis, margine sterile integra, fertile crenata; soris magnis, paucis, partes distales sed apices ipsas rarissime segmentorum occupantibus, utraque facie laminae perconspicuis, marginalibus sed inferne potius quam lateraliter apertis, ore valde elevato in maturitate fere orbiculare circumdatis.

LUZON, Benguet, Pauai, altitude 2,350 meters, *Copeland, P. P. E. 149*, May 9, 1909; also Mount Bulusan (prope Pauai), altitude 2,500 meters, *Copeland, s. n.*, May, 1913.

The specimens fit Hayata's description and figures perfectly except as to the pubescence of the paleæ; as to this, his figure is perhaps not accurate.

This species is a *Prosaptia*, rather than a *Polypodium*, if the usual generic boundary is to be maintained, in spite of the fact that its sori open obliquely toward the nether surface and the apex of the segments and the margin, rather than distinctively laterally. In this respect, it is like *P. alata* and its near relatives, rather than like *P. contigua*. In the absence of any conspicuous wing at the base of the frond, it is like *P. contigua* and unlike

P. alata. The sterile apex of the segments is a distinctive character, probably associated with the extreme prominence of the sori. Except when the very abundant sporangia conceal it, the rim of the sorus is fully as conspicuous as in *P. celebicum,* with which *P. craterisorum* Harr. is completely synonymous. *Prosaptia bolsteri* is probably a small *P. alata*—small because imperfectly developed, rather than fixed as even a local variety. As to the near affinity of *Prosaptia* and *Cryptosorus,* Hayata, l. c., lays down in more detail facts to which I had already (as had J. Smith and others before me) paid attention. It does not necessarily follow from these facts that *Polypodium* is the proper name of this fern. The selection of boundary lines between genera is usually facilitated for us by our not having before us the steps through which daughter groups have evolved from their parents. However, we would not abandon our practice of recognizing genera if our knowledge of all such steps were perfect, and convenience may provide ample justification for our maintaining as distinct genera the comparatively few markedly peculiar derived groups which we can connect with their parents by an approximately continuous series of living species. Some of us have observed such an artificial boundary, somewhere between *Polypodium obliquatum* and *Prosaptia alata, Prosaptia contigua* representing the "type" reached by evolution in its direction. My present judgment is that Christensen, Mittheilungen Inst. Allegen. Bot. Hamburg 7 (1928) 158, has proposed a better place for this line, nearer the parent group, so as to include (in *Prosaptia*) *Polypodium obliquatum* and its immediate relatives. The same author is absolutely right, Dansk. Bot. Arkiv. 5, No. 22 (1928), in the opinion that the type of *Polypodium* is far more nearly related to a group often called (whether or not properly) *Goniophlebium* than to the very large group of small tropical epiphytes sometimes distinguished as *Ctenopteris.* Our present enormous genus *Polypodium* will be broken up. When this is done, with due regard to phylogeny, convenience, and any rules of nomenclature, the alternative to recognizing *Prosaptia* as a genus, with species counted by the dozen, will be its extension to include several hundred species.

VITTARIA STENOPHYLLA Copeland sp. nov.

Taenioupsis, rhizomate repente, paleis castaneis griseo-iridescentibus 5 mm longis e basi 0.5 mm lata ad apicem filiformem sensim attenuatis; frondibus densissime caespitosis, usque ad 15 cm longis, 1.5 mm latis, apice valde acuminatis sterilibus, basi

ad stipites 0–3 cm longus sensim angustatis, inconspicue costatis; soris intramarginalbus, leviter immersis, utroque latere costae partem majorem longitudinis occupantibus, paraphysibus turbinatis oleaginis.

LUZON, Benguet, Mount Santo Tomas, altitude 2,300 meters, *Copeland P. P. E. 122* (type), May 1909, epiphytic on *Cyathea* trunks in mossy forest; also, in Lepanto, near Bagnen, *Copeland 1928,* November, 1905.

Similar to *V. angustifolia* Blume, from which it is most evidently distinguishable by smaller and darker paleæ. *Vittaria alternans* is notably slenderer. The very slender and sharp sterile apices, commonly about 2 centimeters long, are a conspicuous character of *V. stenophylla.* At the base, the fronds merge insensibly into stipes about 0.25 millimeter wide but without definite length.

ILLUSTRATIONS

[All plates are from photographs by W. C. Matthews. The scale is indicated by the centimeter scale on each photograph. The enlargement of detail drawings is proportional; that is, they are drawn magnified as stated on the drawings and then photographed down with the rest of the plate.]

PLATE 1. GLEICHENIA PELTOPHORA COPELAND. TYPE.

PLATE 2. DRYOPTERIS ELMERORUM COPELAND. TYPE.

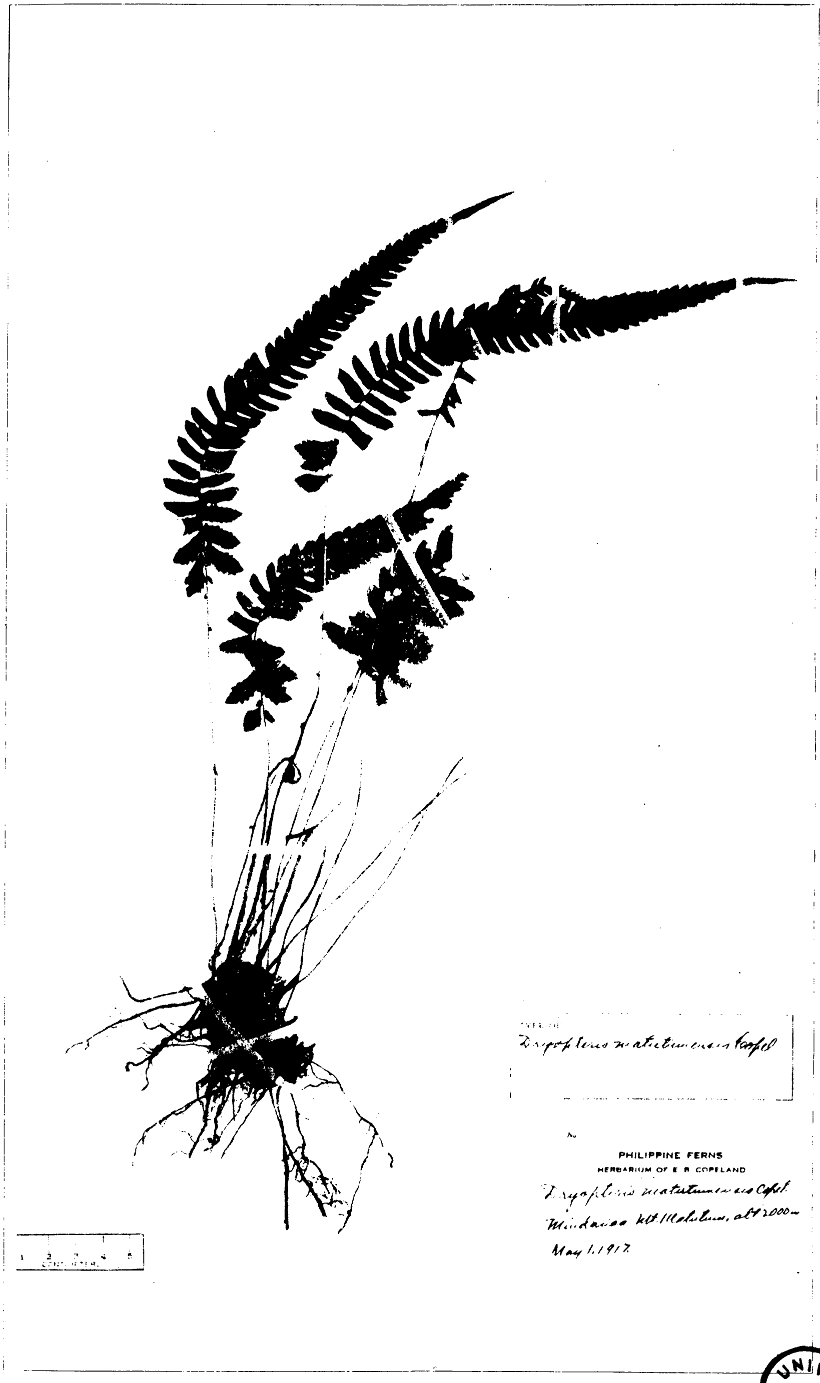

PLATE 3. DRYOPTERIS MATUTUMENSIS COPELAND. TYPE.

PLATE 4. ATHYRIUM GYMNOCARPUM COPELAND. TYPE.

PLATE 5. ATHYRIUM OREOPTERIS COPELAND. TYPE.

PLATE 6. ATHYRIUM CALLIFOLIUM COPELAND. TYPE.

PLATE 7. CAMPIUM MEMBRANACEUM COPELAND. TYPE.

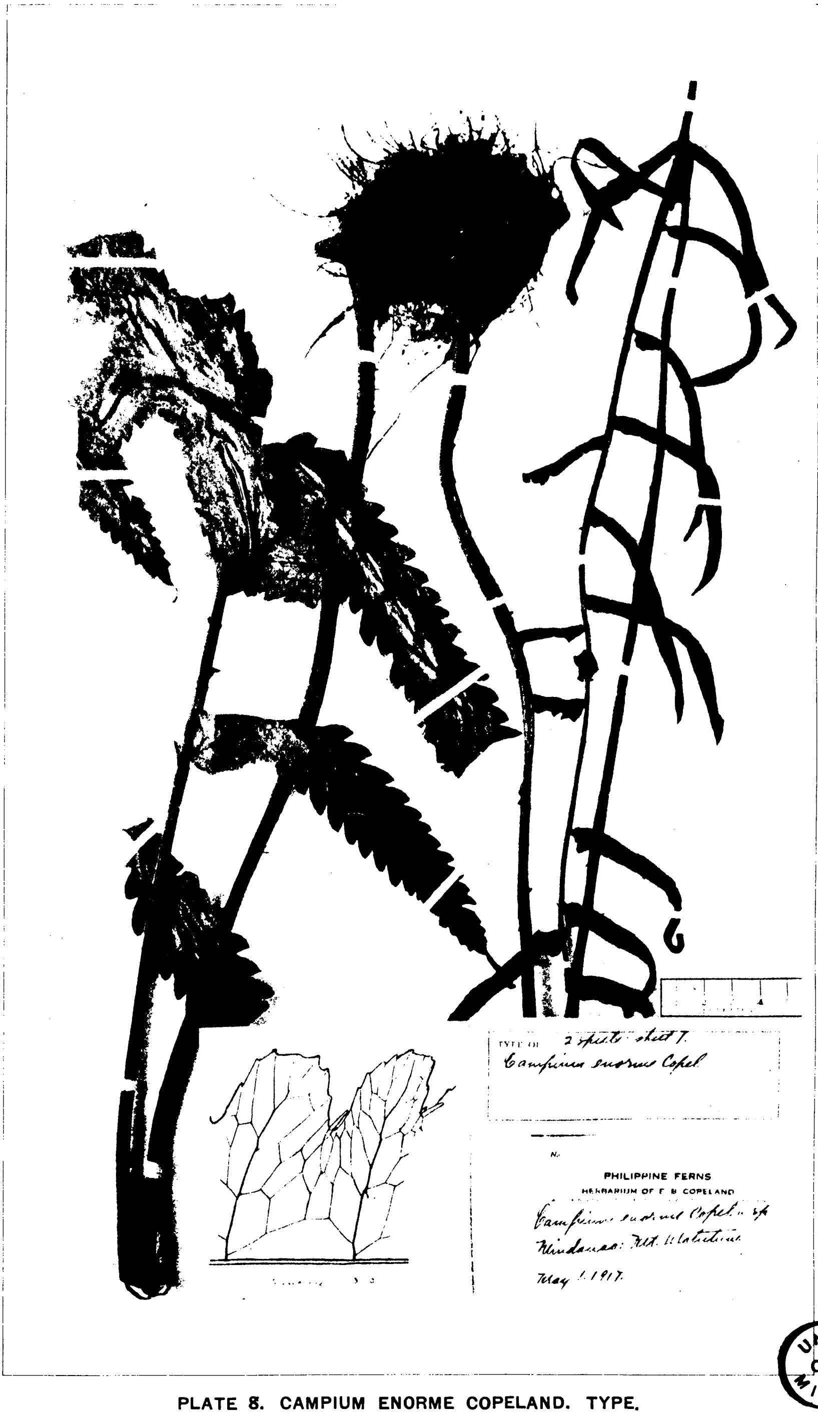

PLATE 8. CAMPIUM ENORME COPELAND. TYPE.

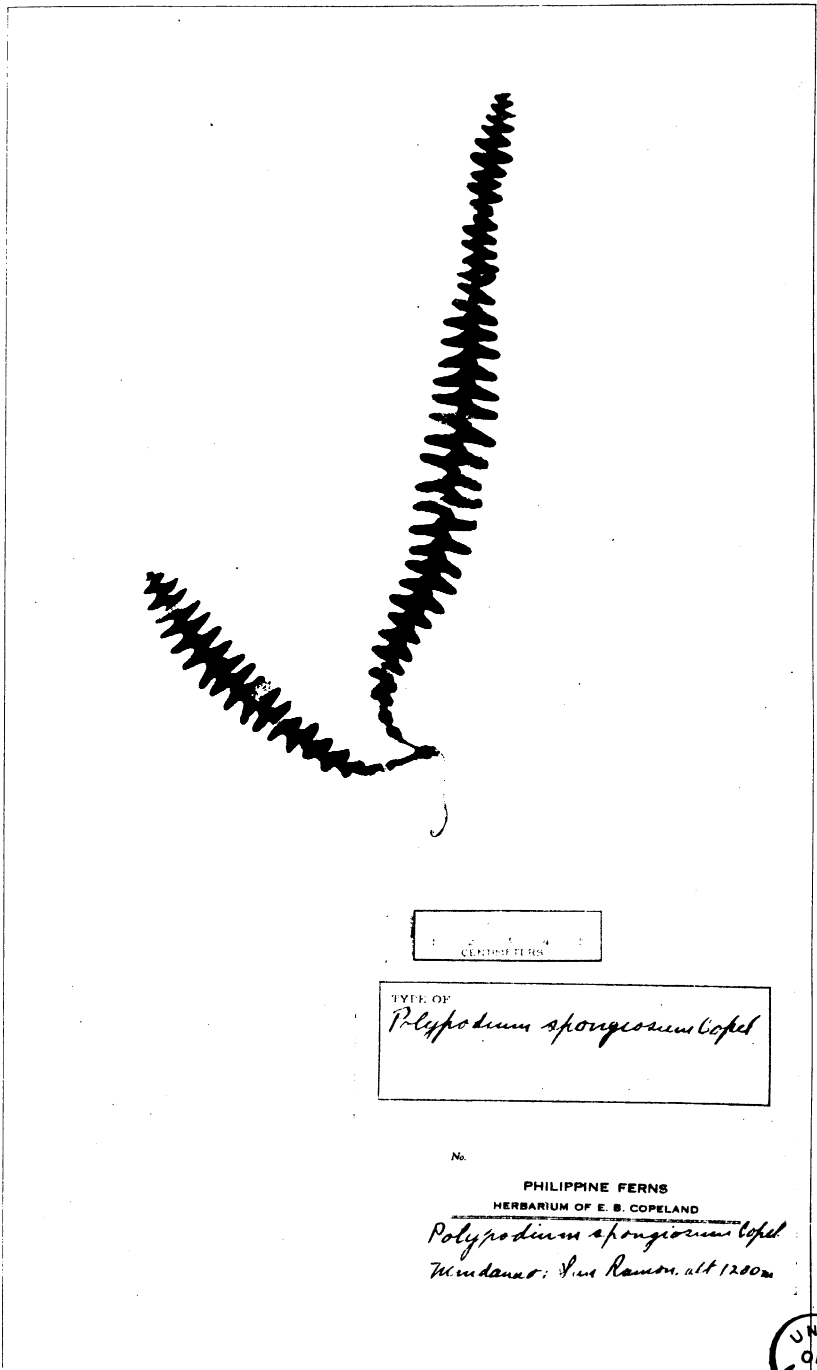

PLATE 9. POLYPODIUM SPONGIOSUM COPELAND. TYPE.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), IV [1]

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THREE PLATES

The crane flies discussed at this time are from various parts of eastern and southern Asia and were received from the following entomolgists and collectors: China, Messrs. A. P. Jacot, E. Suenson, and T. Yokoyama; Japan, Messrs. Teiso Esaki, C. Harukawa, S. Kuwayama, Jiro Machida, Akio Nohira, S. Sakaguchi, and E. Suenson; Formosa, Messrs. S. T. Issiki and K. Takeuchi; Philippines, Messrs. Duyag, McGregor, and Rivera; and India, Mr. C. F. C. Beeson and the authorities of the Indian Museum. I wish to express my deepest thanks to all of the above-named gentlemen for the opportunity of studying the great collections of crane flies upon which the following descriptions are based. Except where stated to the contrary, the types of the novelties are preserved in my collection.

The crane-fly fauna of the Oriental Region is tremendously large and varied, more especially so on the slopes and summits of the higher mountains where a characteristic Palæarctic element is found. There can be little question that this region, with its abundant isolated mountain ranges, major islands, and archipelagoes, separated for past ages and having had an abundance of time for the formation of species, will be found to support a greater number of species of Tipulidæ than any other region of the World.

TIPULINÆ

TIPULINI

BRITHURA SANCTA sp. nov.

General coloration dark clove-brown, the præscutum with three paler reddish brown stripes; pleura light brown with two narrower dark brown longitudinal stripes; femora yellowish brown, the tips narrowly blackened, preceded by a clearer yellow sub-

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

terminal ring; wings with Sc_1 present; Rs subequal to R_3, the latter angulated and short-spurred near outer end; male hypopygium large, the sternal region only moderately produced.

Male.—Length, excluding head, about 26 millimeters; wing, 23 by 6. Head broken.

Pronotum yellow, the posterior notum with two approximated median tubercles that are dark brown, the anterior notum darkened laterally. Mesonotal præscutum dark clove-brown with three nearly confluent reddish brown stripes, the dark ground color restricted to the humeral and lateral regions; median stripe broad; scutum chiefly reddish brown; scutellum dark reddish brown, more blackened medially, the parascutella black; postnotal mediotergite dark brown, the posterior portion with an obscure yellow triangle. Pleura light brown with two narrow darker brown longitudinal stripes, the more dorsal lying just beneath the dorsopleural membrane, including the propleura; ventral stripe including the fore coxæ, continued across the sternopleurite to the metapleura; pleurotergite elevated, the anterior face with an appressed yellow pubescence. Halteres light reddish brown, the base of each knob darker. Legs with the coxæ dark brown; trochanters paler, especially the fore trochanters; femora yellowish brown, the base and a subapical ring clearer yellow, the tip narrowly blackened; tibiæ brown, the base yellow; tarsi brown. Wings (Plate 1, fig. 1) as in the genus; costal region opposite the stigma dilated but not broken; ground color yellow, with a sparse dark pattern, including the bases of cells R and M; origin of Rs; a large area extending from the stigma across the cord; outer ends of all outer cells from R_3 to 2d A inclusive infumed, most of them inclosing small marginal yellow areas; medial veins beyond the cord narrowly bordered by yellow, which in turn has a dusky margin, darker than the centers of the cells; a conspicuous darkened area on either side of vein 1st A at near midlength; veins yellow, the costal vein more reddish brown. Venation: Sc_1 present; Rs strongly arcuated, subequal to R_3, the latter angulated and short-spurred just before apex; cell 1st M_2 higher than long.

Abdominal tergites brownish black; hypopygium conspicuously reddish; sternites reddish brown. Male hypopygium (Plate 2, fig. 19) relatively large but ninth sternite, *9s*, not greatly developed, as is the case in *B. crassa* Edwards. Ninth tergite *9t*, narrowed outwardly, the caudal margin with a deep U-shaped emargination that is fringed with conspicuous erect yellow setæ, the lateral lobes thus formed relatively conspicuous. Basistyle,

b, produced, the apex flattened, provided with long yellow setæ. Dististyle, *d*, shiny reddish brown, very large and complex in structure. Ninth sternite, *9s*, produced into a median tubercle of moderate size.

Habitat.—China (Chi li).

Holotype, male, Ton Che ssu, a temple in hills west of Peking, August 27, 1921 (*A. P. Jacot*).

Brithura sancta differs from *B. nymphica* Alexander, which seems to be its nearest relative, in the details of coloration and venation, especially the retention of Sc_1 and the arrangement of veins in the radial field. The venation of *B. conifrons* Edwards, the genotype, is shown for comparison (Plate 1, fig. 2).

TIPULA SUBFUTILIS sp. nov.

Allied to *T. futilis* Alexander; antennæ with the basal segments of the flagellum bicolorous; wings with a complete white crossband beyond the cord; distal end of R_{1+2} atrophied; male hypopygium with the lateral lobes of the ninth tergite very low and obtuse, the caudal margin notched, with two small submedian ridges; gonapophyses blackened, simply bispinous.

Male.—Length, about 13 millimeters; wing, 16 by 3.7.

Described from an alcoholic specimen.

Frontal prolongation of head relatively long, brownish yellow; palpi pale. Antennæ of moderate length, if bent backward extending to shortly beyond the base of the abdomen; basal segment yellow; second scapal segment brown; first flagellar segment yellow; succeeding segments brown, the distal end yellow, the amount of the latter decreasing on the outer segments, on the second flagellar including only the distal fourth; beyond the fifth flagellar, the segments are entirely brown; terminal flagellar segment very small, oval. Head brownish gray; vertical tubercle low and obtuse, entire.

Mesonotal præscutum pale brown, with three paler, more brownish yellow stripes that are ill-defined against this background; scutellum and postnotum yellowish brown, with a delicate brown median vitta. Pleura uniformly brownish yellow, possibly pruinose in dry specimens. Halteres chiefly pale. Legs with the femora brownish yellow, clearer basally, darker at tips; tibiæ and tarsi passing into dark brown. Wings relatively long and narrow, as shown by the measurements; pattern almost as in *T. futilis*, the ground color brownish, variegated with whitish subhyaline, this latter including a complete crossband beyond the cord; smaller pale areas in cell R, before the stigma; near outer end of cell M; at outer end of cells Cu and 1st A, crossing

the latter vein; and at midlength of cell 1st A, not touching the veins; darker areas than the ground color at origin of Rs, anterior cord and as a conspicuous seam along the distal half of Cu_1. Venation: R_{1+2} pale at base, scarcely visible, the outer end entirely atrophied; R_2 short, perpendicular.

Abdominal tergites obscure yellow with a narrow but conspicuous median brown line that is nearly continuous; sternites more uniformly yellow. Male hypopygium (Plate 2, fig. 20) with the ninth tergite (Plate 2, fig. 21) extensive, gradually narrowed outwardly, the caudal margin with a very shallow emargination, the lateral lobes thus formed very low and obtuse; a very small rounded tooth on either side of the median line, these produced back onto the dorsal surface of the tergite as short ridges that inclose a narrow linear furrow. Outer dististyle widely expanded outwardly. Gonapophyses, *g*, appearing as heavily blackened structures that lie on either side of the ædeagus, each apophysis bispinous, the more dorsal spine a little longer.

Habitat.—Japan (Kiushiu).

Holotype, alcoholic male, Unzen Park, Hizen, May, 1926 (*E. Suenson*), received through Doctor Crampton.

Tipula futilis Alexander (Japan) differs from the present species in the details of structure of the male hypopygium. In *T. futilis*, the caudal margin of the ninth tergite (Plate 2, fig. 22) is more deeply and evidently notched, the margin heavily blackened, the lateral lobes more conspicuous; the base of the notch bears a small black median tooth, in addition to two smaller and blunter sublateral knobs; dorsal surface not evidently ridged and furrowed as in *subfutilis*. Outer dististyle (Plate 2, fig. 23) quite as in *T. subfutilis*. Inner dististyle, *id*, with the ventral margin produced into a stout lobe that ends in a nearly terminal black spine. Gonapophyses, *g*, with the dorsal arm bifid, the ventral arm longer and slenderer than in *T. subfutilis*.

TIPULA YUSOUOIDES sp. nov.

Male.—Length, about 14 millimeters; wing, 17.

Female.—Length, about 20 millimeters; wing, 19.

Described from alcoholic specimens.

Closely allied and generally similar to *T. yusou* Alexander (Japan), differing chiefly in the structure of the male hypopygium.

Male hypopygium (Plate 2, fig. 24) with the caudal margin of the ninth tergite arched and heavily blackened, as in *T. yusou*,

the dentation of the margin quite different, the most ventral tooth on either side being much larger and produced into an acute spine. Outer dististyle smaller, more dilated before apex. Inner dististyle, *id*, with the blade much smaller, the bilobed apex heavily blackened and relatively small. Eighth sternite, *8s*, with the caudal lobe longer than broad, clothed with abundant long golden setæ.

Habitat.—Japan (Kiushiu).

Holotype, male, Unzen Park, Hizen, May, 1926 (*E. Suenson*). Allotopotype, female.

In *Tipula yusou* Alexander [2] the caudal margin of the tergite is highly arched, narrowly blackened, with numerous small teeth and lobules, none of which is acute. Outer dististyle elongate, gradually widened outwardly. Inner dististyle large, the blades conspicuous. Eighth sternite with the caudal lobe transverse, the setæ chiefly marginal.

TIPULA SUBYUSOU sp. nov.

Male.—Length, about 16 millimeters; wing, 18.

Closely allied to *T. yusou* Alexander (Japan), differing especially in the structure of the male hypopygium.

Ninth tergite with the caudal margin narrowly darkened or blackened but without distinct denticles. Outer dististyle nearly as in *T. yusouoides*, being rather conspicuously dilated just beyond midlength. Inner dististyle with the outer marginal lobe intensely blackened, obtusely rounded, the caudolateral margin bearing a pale lateral flange. Eighth sternite with the caudal lobe transverse, its margin with a dense brush of long golden setæ. Gonapophyses (Plate 2, fig. 25) trifid, as in *T. yusou*, but the arms much longer and slenderer, arising from a long, heavily blackened base, the arms gently curved and slightly decurved. In *T. yusou* (Plate 2, fig. 26), the gonapophyses are paler and nearly straight, the longer median spine subtended by the lateral spines.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Takao, altitude 1,000 to 2,000 feet, May 7, 1922 (*Teiso Esaki*). Paratype, male, Nakano, Tokyo, May 1, 1922 (*Teiso Esaki*).

TIPULA RANTAICOLA sp. nov.

General coloration ocherous yellow, the præscutum with ill-defined darker stripes; antennæ bicolorous; wings grayish brown,

[2] Canadian Entomologist 46 (1914) 240–241, pl. 19, fig. 1.

certain of the veins seamed with darker; cell 1st M_2 very small; male hypopygium with the median region of the tergite produced into a decurved setiferous lobe.

Male.—Length, about 9 to 10 millimeters; wing, 9 to 10.

Female.—Length, about 11 millimeters; wing, 11.

Frontal prolongation of head brownish yellow; palpi dark brown. Antennæ with the scape yellow; flagellum weakly to strongly bicolorous, the basal enlargement of each segment brownish black, the remainder brownish yellow to yellow; antennæ (male) relatively elongate, if bent backward extending to some distance beyond base of abdomen; antennæ (female) shorter, distinctly bicolorous. Head brownish gray, clearer gray in front; a narrow dusky median line on anterior vertex.

Mesonotal præscutum ocherous yellow, the three usual stripes only a trifle darker, the median stripe split by a capillary, slightly darker vitta; scutal lobes extensively darkened; scutellum and postnotum brown. Pleura brown. Halteres yellow, the knobs infuscated, their apices pale to distinctly yellow. Legs with the coxæ and trochanters yellow; femora yellow, passing into dark brown; tibiæ and tarsi dark brown. Wings (Plate 1, fig. 3) with a grayish brown suffusion, the base and costal region more yellowish; cell C a trifle infumed; stigma conspicuous, dark brown; outer end of cell R_2 darkened; conspicuous brown seams on Cu, m-cu, and more narrowly on most other longitudinal veins; extensive whitish areas before and beyond the stigma and across cell 1st M_2; veins dark brown, the obliterative areas whitish, the veins in the yellowish areas more flavous. Macrotrichia of veins very long and abundant. Venation: Cell 1st M_2 very small, diamond-shaped to pentagonal.

Abdominal tergites obscure yellow, the lateral and caudal margins of the segments blackened, the amount increasing on the outer segments; sternites yellow, the caudal margins of the segments a little darkened; eighth sternite blackened; hypopygium chiefly pale. Male hypopygium small, the median region of the tergite produced into a conspicuous decurved lobe, the sides of which are densely clothed with conspicuous yellow setæ. Inner dististyle large, jutting caudad as large, compressed to slightly tumid lobes, the apex of each with a small group of black spinous setæ, this lobe much larger than the flattened outer dististyle. Eighth sternite unarmed.

Habitat.—Formosa.

Holotype, male, Rantaizan, altitude 7,000 feet, June 2, 1927 (*S. T. Issiki*). Allotopotype, female. Paratopotypes, 4 males.

Tipula rantaicola bears a marked resemblance to *T. microcellula* Alexander (Plate 1, fig. 4) in the general appearance and very small cell 1st M_2, differing especially in the details of coloration, wing venation, and the structure of the male hypopygium, especially the ninth tergite which here bears a setiferous median lobe.

NESOPEZA RANTAIZANA sp. nov.

General coloration ocherous, the mesonotal præscutum with a median darker line; antennæ (male) relatively long; legs brown, the tibiæ and tarsi extensively white; wings nearly hyaline, the stigma brown; free tip of Sc_2 nearly atrophied, indicated only by a pale line; basal section of R_{4+5} and r-m pale, without macrotrichia, in transverse alignment; forks of medial field relatively shallow, male hypopygium with the tergite produced laterad into slender blackened rods, the median area of the caudal region further produced into a decurved point.

Male.—Length, about 8 millimeters; wing, 10.

Rostrum testaceous yellow; palpi pale brown. Antennæ with the scapal segments yellow, the flagellum dark brown; antennæ 12-segmented, the terminal segment small; flagellar segments with dense short setæ and longer unilaterally arranged black verticils that are conspicuous but scarcely one-half the length of the segment. Head ocherous yellow.

Thorax almost uniformly ocherous, the præscutum with a median darker line; pleura more testaceous. Halteres very long and slender, pale brown, the knobs darker. Legs with the coxæ and trochanters yellowish testaceous; femora brown; posterior tibiæ dusky, the extreme tips white; tarsi dusky, the tips paling to white; on the other legs the amount of white on the tibiæ and tarsi appears to be more extensive. Wings (Plate 1, fig. 5) relatively broad, nearly hyaline, the oval stigma brown; veins brown, unusually slender, with long conspicuous macrotrichia. Macrotrichia on the distal third of vein M, distal half of basal section of Cu_1, and outer ends of both anal veins. Venation: Sc_2 ending opposite four-fifths the length of Rs; free tip of Sc_2 atrophied or barely visible; basal section of R_{4+5} and r-m pale, without macrotrichia, in transverse alignment; forks of medial veins relatively shallow; m-cu subtransverse; cell 2d A narrow.

Abdomen yellowish brown, darker laterally. Male hypopygium with the lateral margins of the tergal region produced caudad and slightly mesad into slender blackened arms, their

tips microscopically spiculose; median region of tergite with a broad-based acute median point that is directed ventrad, the margin of the tergite dorsad of this with a fringe of long erect setæ; tergite pale except for the blackened lateral and caudal margins. Outer dististyle relatively short and inconspicuous, cylindrical, the apex truncate. Inner dististyle deeply bifid.

Habitat.—Formosa.

Holotype, male, slightly teneral, Rantaizan, altitude, 7,000 feet, June 2, 1927 (*S. T. Issiki*).

NESOPEZA IDIOPHALLUS sp. nov.

General coloration dark brown; antennæ with the scapal segments yellow, the flagellum dark brown; front and anterior vertex conspicuously yellow; mesonotum chiefly dark brown, median area of the præscutum and scutum paler; pleura pale brownish yellow, the anepisternum and sternopleurite conspicuously dark brown, legs dark brown, the tarsi extensively snowy white; male hypopygium with the ædeagus conspicuous, subtended on either side by a flattened spinous arm.

Male.—Length, about 10 millimeters; wing, 11.5.

Female.—Length, about 15 millimeters; wing, 13.

Frontal prolongation of head brown, entirely without nasus; palpi dark brown. Antennæ (male) of moderate length, if bent backward extending about to the base of the abdomen; scapal segments pale yellow, the flagellum dark brown; flagellar segments elongate-cylindrical, the basal enlargements of the segments inconspicuous, the verticils scattered, shorter than the segments. Front and anterior vertex pale yellow; remainder of head dark brown.

Pronotum brown, the posterior notum more yellowish. Mesonotal præscutum dark brown, the median area somewhat paler; scutum dark brown, the median region paler; posterior sclerites of mesonotum testaceous brown. Pleura pale brownish yellow, with a broad transverse dark brown girdle that includes the anepisternum and sternopleurite; meron similarly darkened. Halteres pale, the knobs dark brown. Legs with the coxæ yellow, a little darkened at base; trochanters yellow; femora dark brown, their bases paler; tibiæ and tarsi dark brown, the distal fifth of the basitarsi and remaining tarsal segments snowy white. Wings with a strong brownish suffusion, the oval stigma darker brown; ill-delimited dark clouds on anterior cord and m-cu; whitish obliterative areas before and beyond the stigma and across the fork of M. Venation: Rs of moderate length, about

one-half longer than R_{2+3}; forks of medial cells relatively shallow; m-cu about one-third its length before the fork of M.

Abdominal tergites brown, the incisures, including the broad base and narrower apex of each segment, more blackened; subterminal segments black; hypopygium obscure yellow, including the conspicuous ædeagus. Ædeagus (Plate 2, fig. 27) very conspicuous, jutting caudad and ventrad from the genital chamber, long, pale yellow, at near midlength subtended on either side by a flattened yellow blade that is bispinous at and near apex. Ovipositor with the tergal valves relatively short and wide, their tips obtuse.

Habitat.—China (Che-kiang).

Holotype, male, hills south of Ning-po, May 1, 1925 (*E. Suenson*). Allotopotype, female.

OROPEZA SATSUMA Alexander.

Oropeza satsuma ALEXANDER, Journ. New York Ent. Soc. 26 (1918) 67–68.

The holotype was from Kioto, Japan, July, 1916 (*Akio Nohira*). The male hypopygium of the type was not discussed and may be briefly described as follows: Male hypopygium (Plate 2, fig. 28) with the ventrolateral angles of the tergite produced ventrad, caudad, and mesad into a curled flattened ribbonlike plate; mesal region of sternite produced strongly ventrad. Outer dististyle, *od*, pale, of moderate length only, narrowed gradually to the obtuse apex, provided with abundant long pale setæ. Ninth tergite (Plate 2, fig. 29) entirely pale, the caudal margin subtransverse, crenate, with a very low and shallow median notch and still smaller, more circular, sublateral incisions; the major incisions that separate the caudal margin from the flattened ventrolateral arms are even deeper.

OROPEZA BISPINULA sp. nov.

General coloration dark brown, the præscutum with three still darker stripes; tibiæ and tarsi brown; wings with a pale brown suffusion, the stigma dark brown, preceded and followed by conspicuous pale yellow areas; abdomen beyond base deepening to black; male hypopygium with the caudal margin of the ninth tergite with two black, needlelike points.

Male.—Lenght, about 10.5 millimeters; wing, 10.5

Rostrum and palpi dark brown. Antennæ with the scapal segments yellow, the flagellum dark brown; flagellar segments cylindrical, the outer segments gradually shortened; verticils

a little shorter than the segments; antennæ of moderate length, if bent backward extending about to the root of the halteres. Head light brown.

Mesonotal præscutum dark brown, subnitidous, with three brownish black stripes; scutum, scutellum, and postnotum uniformly dark brown. Pleura dark liver brown, the dorsopleural membrane pale. Halteres pale, the knobs brown. Legs with the coxæ concolorous with the pleura; trochanters yellow; femora dark brown, the tips broadly more yellowish; tibiæ and tarsi brown. Wings (Plate 1, fig. 6) with a pale brown suffusion, the base and costal region a little more saturated; stigma oval, dark brown; conspicuous pale yellow antestigmal and poststigmal areas, the latter including more than the basal half of cell Sc_2; veins dark. Venation: Rs transverse, opposite Sc_2; R_1 and R_2 in nearly transverse alignment; R_{1+2} entirely atrophied.

Abdomen with the basal tergites obscure brownish yellow, beyond the second segment reddish brown, gradually deepening to black; sternites beyond the basal segment obscure yellow with narrow black cross lines near base and at margins; outer sternites uniformly darkened; male hypopygium with the inner dististyle, *id*, yellowish, the remainder chiefly dark. Male hypopygium (Plate 2, fig. 30) with the caudal margin of the ninth tergite, *9t*, nearly transverse, the median area blackened, chitinized, produced into two slender, needlelike points, one on either side of the median line (Plate 2, fig. 31).

Habitat.—Japan (Honshiu).

Holotype, male, Lake Ozenuma, on boundary between Iwashirono-kuni and Kotsuke-no-kuni, altitude 5,410 feet, July 25, 1923 (*Teiso Esaki*).

OROPEZA SAUTERI Riedel.

Oropeza sauteri RIEDEL, Archiv für Naturgeschichte 82 (1917) 114–115.

Riedel's types, both sexes, were from Okaseki, Taihoku District, Formosa, collected in June, 1914, by Sauter. I have seen additional males and females from Taihoku, taken April 20, 1922, by K. Takeuchi.

These latter specimens agree very closely with Riedel's description except that the incisures of the abdomen are not darkened but the narrow transverse dark marking of each segment lies at or before midlength of the segment, the base and apex being broadly yellowish. The sternities are extensively brown at the base and very narrowly so at the apex, with a conspicuous

yellowish ring before the apex; subterminal segments more uniformly darkened; hypopygium small, chiefly obscure yellow. Male hypopygium with the median notch of the tergite small, U-shaped with no distinct notches or incisions laterad of this; ventrolateral arms of tergite terminating in large oval heads.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) RANTAIENSIS sp. nov.

Mesothorax shiny black; halteres yellow; legs black, the broad femoral bases, a subterminal femoral ring, and the narrow bases of the tibiæ yellow; wings yellowish, the veins seamed with brown; Sc short; R_{1+2} elongate.

Female.—Length, about 9 millimeters; wing, 9.3.

Rostrum and palpi black. Antennæ with the scape black, the basal flagellar segments black with their tips somewhat more brownish; flagellar segments oval, the verticils considerably longer than the segments. Head brownish black, not nitidous; anterior vertex a little wider than the first scapal segment.

Pronotum black, more pruinose laterally. Mesonotum black, nitidous, only the dorsopleural region restrictedly paler. Pleura black. Halteres yellow, the knobs orange-yellow. Legs with the fore coxæ black; middle coxæ darkened basally; hind coxæ and all trochanters yellow; femora with more than the basal half yellow, the remainder black, inclosing a conspicuous yellow ring about its own length before the apex; tibiæ black, the extreme base yellow; tarsi black. Wings (Plate 1, fig. 7) yellow, the base and costal region somewhat brighter; an extensive brown pattern distributed as follows: Broad seams along Rs, R_{2+3}, and R_3, confluent with the small and ill-defined stigma; cord, outer end of cells 1st M_2, and longitudinal veins beyond cord seamed with brown; broad seams on Cu_1, interrupted at base and before end of basal section of vein; broad seams at ends of both anal veins and in the axilla; veins brown; yellow in the basal and costal regions. Venation: h indistinct; Sc relatively short, Sc_1 extending to about opposite one-fourth the length of the strongly arcuated Rs, Sc_2 close to its tip; R_2 only about one-third to one-fourth of R_{1+2}; cell 1st M_2 closed; m-cu shortly before fork of M.

Abdominal tergites brownish black, the segments variegated medially and caudally with yellow, the ground color more or less restricted to large basolateral areas; genital segment and ovipositor pale reddish yellow; sternites obscure yellow; base of

sternal valves of ovipositor blackened. Ovipositor with the tergal valves unusually slender, acicular, nearly straight.

Habitat.—Formosa.

Holotype, female, Rantaizan, altitude 6,000 feet, June 3, 1927 (*S. T. Issiki*).

Limonia rantaiensis is well distinguished from allied regional species by the shining black mesothorax, short Rs, long R_{1+2}, and the wing and leg pattern.

LIMONIA (DICRANOMYIA) TRISTOIDES sp. nov.

Allied to *L.* (*D.*) *tristis* Schummel; general coloration gray, the præscutum with three brown stripes; legs chiefly brownish black, the femoral bases yellow; wings subhyaline, the stigma reduced or lacking; veins pale brown; male hypopygium with the spines of the rostral prolongation of the ventral dististyle united for a short distance at base, arising from long basal tubercles.

Male.—Length, about 5.2 millimeters; wing, 6.1.

Rostrum and palpi dark brown. Antennæ dark brown, the second segment more reddish apically; flagellum black; flagellar segments oval, the outer segments more elongate. Head light gray.

Mesonotal præscutum yellowish gray with three brown stripes, the median stripe longer and broader; scutellum brown, paler behind; postnotum gray. Pleura gray, vaguely marked with brown. Halteres long, entirely pale. Legs with the coxæ reddish brown; trochanters yellow; femora yellow at base, passing into black, most extensively blackened on fore femora, only the apices of middle and hind femora blackened; tibiæ and tarsi brownish black; legs long and relatively stout. Wings (Plate 1, fig. 8) subhyaline, the stigmal area greatly reduced or lacking; veins pale brown. Venation: Sc_1 ending opposite origin of Rs, the latter relatively long, about two and one-half times the basal section of R_{4+5}; cells 1st M_2 closed; m-cu oblique, at fork of M, shorter than the distal section of Cu_1.

Abdomen dark brown, the hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 32) with the tergite, 9*t*, transverse, the caudal edge narrowly margined with chitin and provided with setæ, including a small median group; caudal margin of tergite gently emarginate. Basistyle, *b*, relatively long, with a single fingerlike lobe shorty beyond midlength, this tufted with setæ; mesal apical angle of basistyle with about four setigerous punctures but not produced into a tubercle; ventromesal lobe of basistyle large, setiferous. Dorsal dististyle, *dd*, much

stouter than in *L. subtristis*, curved to the acute apex. Ventral dististyle, *vd*, unusually low, pale, produced into the blackened rostral prolongation, the latter bearing two long black spines at near midlength, these arising from a very short common base, both from elongate basal tubercles; inner spine a little shorter than the outer. Gonapophyses, *g*, very broad, the mesal apical angle produced into a short blackened hook.

Habitat.—Manchuria.

Holotype, male, Koshurei, Kongchuling, altitude 625 feet, July 25, 1924 (*T. Yokoyama*).

Limonia tristoides is most closely alied to *L.* (*D.*) *subtristis* Alexander (northern Japan), differing especially in the details of structure of the male hypopygium, as the transverse emarginate ninth tergite, the short stout dorsal dististyle, and the low oval ventral dististyle with the long black rostral spines quite distinct in their structure and origin.

LIMONIA (GERANOMYIA) TENUISPINOSA sp. nov.

General coloration of mesonotum reddish brown, the præscutum with three narrow brownish black stripes; pleura yellow with a broad dark brown dorsal stripe; legs yellow; wings grayish yellow with a heavy, chiefly costal pattern; Sc long; m-cu far before the fork of M; abdominal tergites dark brown; male hypopygium with the spines of the rostral prolongation very long and slender, the outermost arising from a large swollen tubercle that is subequal in size to the prolongation beyond it.

Male.—Length, excluding rostrum, about 6 millimeters; wing, 7; rostrum, about 2.5.

Female.—Length, excluding rostrum, about 7.5 millimeters; wing, 7.5; rostrum, about 3.

Rostrum black; maxillary palpi black, 2-segmented. Antennæ with the basal segment black; second segment dark brown; flagellum obscure yellow, the outer segments darkened; flagellar segments short-oval, the outer segments more elongate. Head dusky gray, the narrow anterior vertex clearer gray.

Mesonotal præscutum reddish brown with three conspicuous brownish black stripes, the median stripe narrowed to a point at the suture; humeral and lateral regions more yellowish; scutal lobes extensively dark brown; median region of scutum and the scutellum reddish, slightly pruinose, with a continuous capillary brown vitta; postnotum dark plumbeous. Pleura yellow, the dorsal pleurites and membrane occupied by a broad dark brown longitudinal stripe that extends from the pronotum to the ab-

domen, including the pleurotergite. Halteres chiefly pale, the knobs weakly darkened. Legs with the coxæ and trochanters yellow; remainder of legs yellow, only the outer tarsal segments dark brown. Wings grayish yellow, with a dark brown, chiefly costal pattern; a small, scarcely evident dark seam at h; a similar area beyond this in cell Sc; a conspicuous triangular area surrounding the subcostal crossvein; extensive areas at origin of Rs and tip of Sc, these latter confluent or nearly so, especially in cell C; stigmal area very large, long-rectangular; a large area at outer end of vein R_3 and a small circular cloud at end of vein R_{4+5}; narrow and only slightly conspicuous seams at fork of Rs, anterior cord, m-cu, and outer of end cell 1st M_2; veins pale, darker in the infuscated areas. Venation: A supernumerary crossvein in cell Sc at near midlength; Sc long, Sc_1 extending to about two-thirds the length of Rs, Sc_2 at its tip; m-cu more than one-half its length before the fork of M.

Abdominal tergites uniformly dark brown, the sternites obscure brownish yellow, the caudal margins of the segments somewhat paler, the lateral margins narrowly darkened; hypopygium dark. Male hypopygium (Plate 3, fig. 33) with the ninth tergite transverse, the caudal margin with a small U-shaped emargination; setæ mostly marginal but continued to the cephalolateral portions of the tergite. Basistyle, *b*, relatively small, the ventromesal lobe small. Ventral dististyle, *vd*, large, exceeding the basistyle in size; rostral prolongation slender, bearing two spines, the outermost arising from a very large fleshy tubercle that is subequal to the apex of the rostral prolongation itself, the spine very long and slender; the second spine is close to the base of the rostrum, about two-thirds the length of the outer spine, very slender and gently curved. Dorsal dististyle, *dd*, a strongly curved sickle, the extreme tip acute and upturned. Gonapophyses, *g*, pale, the lateral margin of the mesal apical lobe with microscopic roughenings. Ædeagus large, constricted at near midlength.

Habitat.—China (Che-kiang).

Holotype, male, hills south of Ning-po, May 1, 1925 (*E. Suenson*). Allotopotype, female. Paratopotype, male.

Limonia tinuispinosa resembles *L.* (*G.*) *avocetta* (Alexander) and allied forms, being most readily separated by the somewhat remarkable structure of the male hypopygium.

LIMONIA (GERANOMYIA) SUENSONIANA sp. nov.

General coloration of mesonotum obscure yellow, the præscutum with three brown stripes; pleura yellow, with a narrow

and relatively ill-defined dorsal brown stripe; legs yellow, the terminal tarsal segments darkened; wings subhyaline, with a heavy costal brown pattern, the areas at origin of Rs and end of Sc widely separate; Sc long, Sc_1 ending nearly opposite the fork of Rs; m-cu far before the fork of M; abdominal tergites bicolorous, their apices broadly darkened; male hypopygium with the rostral prolongation of the ventral dististyle short, the two spines close together, relatively short.

Male.—Length, excluding rostrum, about 6 millimeters; wing, 6; rostrum, about 2.

Rostrum and palpi black, the former slightly paler at tips. Antennæ dark brown; flagellar segments oval to long-oval. Head gray.

Mesonotal præscutum obscure yellow with three brown stripes, the median stripe considerably narrowed behind; lateral stripes narrow, crossing the suture onto the scutal lobes; humeral and lateral regions of præscutum extensively light yellow; scutellum yellow with a brown spot medially at base; postnotum pruinose. Pleura yellow with a relatively narrow and ill-delimited dorsal brown stripe extending from the propleura to the postnotum, including the dorsal pleurotergite. Halteres pale, the knobs and a narrow subbasal ring on stem dark brown. Legs with the coxæ and trochanters yellow; remainder of legs obscure yellow, the terminal two tarsal segments dark brown. Wings (Plate 1, fig. 9) subhyaline, with a fairly heavy, chiefly costal brown pattern that is arranged much as in *tenuispinosa* sp. nov.; the areas at Rs and end of Sc are widely separated; wing tip more extensively darkened, inclosing a pale circular spot in outer end of cell R_3; cord and outer end of cell 1st M_2 interruptedly and narrowly seamed with brown. Venation: Sc very long, Sc_1 ending shortly before the fork of Rs, Sc_2 not far from its tip; m-cu nearly its own length before the fork of M.

Abdominal tergites bicolorous, the bases of the segments obscure yellow, the caudal margins broadly infuscated; subterminal segments more uniformly darkened; hypopygium chiefly dark; sternites pale yellow. Male hypopygium with the ninth tergite transverse, the caudal margin notched, the setæ chiefly confined to the lobes, not reaching the cephalic lateral portions of the tergite. Basistyle small, the ventromesal lobe low. Ventral dististyle very large and fleshy, the rostral prolongation short and blunt, bearing two spines that are placed close together at near midlength of the prolongation, the outer spine a little longer than the inner, both of moderate length, acute at tips.

Dorsal dististyle a strongly curved sickle, the tip suddenly narrowed into an acute point. Gonapophyses with the mesal apical lobe long and slender, the tips narrowed into slender acute points.

Habitat.—China (Che-kiang).

Holotype, male, hills south of Ning-po, May 1, 1925 (*E. Suenson*). Paratopotype, male.

I take great pleasure in naming this interesting crane fly in honor of the collector, Mr. E. Suenson, who has collected numerous Tipulidæ in China and Japan. It is allied to *L.* (*G.*) *semistriata* (Brunetti) and similar species of the Oriental fauna, differing especially in the venation and details of the male hypopygium. The acutely pointed gonapophyses present an unusual character in this involved genus.

LIMONIA (ALEXANDRIARIA) ARGYRATA sp. nov.

Head black, the broad front and posterior orbits silvery; mesonotal præscutum shiny castaneous, the lateral regions yellow; scutal lobes blackened; wings hyaline or nearly so, the stigma a little darker; Sc short, Sc_1 and 2d A long.

Female.—Length, about 5.5 millimeters; wing, 5.4 to 5.5.

Rostrum reddish brown, the basal segment of the maxillary palpus pale, the outer segments black. Antennæ black throughout; flagellar segments oval. Head black, the broad front and wide posterior orbits silvery.

Pronotum shiny yellow. Mesonotal præscutum shiny castaneous, the outer ends of the usual lateral stripes darker; lateral and humeral regions clear yellow; scutal lobes conspicuously blackened, the median region yellow; scutellum testaceous yellow; posnotal mediotergite dark plumbeous medially, margined with paler. Pleura yellow, the sternopleurite and anepisternum more purplish. Halteres short, pale, the knobs a little infuscated. Legs with the coxæ reddish yellow; trochanters obscure yellow; remainder of legs obscure yellow, the outer tarsal segments passing into black. Wings (Plate 1, fig. 10) hyaline or nearly so; stigma pale, scarcely darker than the ground color; veins brown. Venation: Sc short, Sc_1 ending far before the origin of Rs; Sc_1 long, about one-third longer than m-cu; Rs short, arcuated, about one-half the basal section of R_{4+5}; free tip of Sc_2 before the level of R_2; m-cu just before the fork of M; vein 2d A long, the cell wide.

Abdominal tergites dark brown, the sternites obscure yellow, the basal segments a little darker; genital segment yellow. Ovipositor with the tergal valves slender, gently upcurved.

Habitat.—Formosa.

Holotype, female, Urai, altitude about 1,500 feet, April 20, 1922 (*K. Takeuchi*). Paratopotype, female. Paratype, female, Hokuto, 1912 (*H. Sauter*); Deutschen Entomologischen Institute, through Dr. Walther Horn.

LIMONIA (THRYPTICOMYIA) BREVICUSPIS sp. nov.

Size large (wing, male, 7 millimeters or more); general coloration dark brown, the pleura and sternum paler; wings whitish subhyaline; stigma small, dark brown; free tip of Sc_2 not far before R_2, R_1 shortened; apical spur of R_{1+2} elongate; male hypopygium with the spines of the rostral prolongation of the ventral dististyle short and spikelike, placed close together at base of the prolongation.

Male.—Length, about 7 to 7.5 millimeters; wing, 7 to 5.

Rostrum obscure yellow, darker above; palpi brownish black. Antennæ brownish black, the flagellar segments elongate-oval, with pale glabrous pedicels to produce a moniliform appearance. Head dark brown.

Mesonotal præscutum brown, the humeral region paler; posterior sclerites obscure testaceous yellow. Pleura obscure yellow. Halteres dark brown, the stem paler. Legs with the coxæ and trochanters yellowish testaceous; femora brown, paler basally; tibiæ dark brown; basitarsi with about the basal two-fifths dark brown, the remainder of the segment and all remainder of tarsi except the outer segment snowy white; terminal segment darkened. Wings (Plate 1, fig. 11) whitish subhyaline, iridescent; stigma oval, relatively small, dark brown; veins nearly black, with conspicuous macrotrichia. Venation: Sc_1 ending opposite origin of Rs, Sc_2 some distance from its tip; free tip of Sc_2 far distad, R_1 being only about one-half the length of the long apical spur of R_{1+2}; cell 1st M_2 relatively large, m-cu shortly before midlength. In one specimen, the free tip of Sc_2 and R_2 are almost in alignment.

Abdominal tergites brown, the outer segments darker; sternites pale. Male hypopygium (Plate 3, fig. 34) with the rostral prolongation of the ventral dististyle, *vd*, of moderate length, broad at base, the apex narrowed, provided with a conspicuous seta; two rostral spines, placed at the base of the prolongation, only slightly separated; both spines unusually small and spikelike, subequal, the innermost forms a slightly enlarged basal swelling.

Habitat.—Japan (Riukiu Islands).

Holotype, male, Nago, altitude 30 feet, March 18, 1923 (*S. Sakaguchi*). Paratopotypes, 4 males, mostly in poor condition.

Limonia brevicuspis is the largest species of the subgenus *Thrypticomya* so far described.

LIMONIA (EUGLOCHINA) ARACHNOBIA sp. nov.

General coloration dark brown, the pleura paler; legs black, including the proximal ends of all basitarsi; wings strongly infumed, the stigma darker; Rs very short, encircling the proximal end of the stigma; cell 1st M_2 present.

Male.—Length, about 5.8 to 6 millimeters; wing, 6.5 to 6.7.

Rostrum testaceous yellow; palpi black. Antennæ black throughout. Head dark brown.

Mesonotum shiny dark brown, the lateral margins of the præscutum and median region of the scutum paler. Pleura more brownish yellow, shiny. Halteres obscure yellow at base, passing into brownish black. Legs black, the coxæ and trochanters concolorous with the pleura; porximal ends of basitarsi extensively blackened, this including from one-third to approximately one-half the length of the segment. Wings (Plate 1, fig. 12) with a strong dusky suffusion, the large oval stigma still darker; veins dark brown. Venation: Sc of moderate length for a member of this subgenus, the distance on $Sc_2 + R_1$ between Sc_2 and origin of Rs more than one-half longer than R_3; Rs very short, arcuated, bordering the proximal end of the stigma, shorter than the basal section of R_{4+5}; cell 1st M_2 relatively small, rectangular; m-cu beyond one-third the length of the cell; Cu_2 preserved to opposite one-third the length of the basal section of Cu_1.

Abdomen black, the sternites obscure yellow, except laterally and at apex.

Habitat.—Philippines.

Holotype, male, Majayjay, Laguna Province, Luzon, altitude above 500 meters, June 3, 1928 (*R. C. McGregor*). Paratopotype, male, May 28, 1928 (*R. C. McGregor*).

Limonia arachnobia is a very different species from *L.* (*E.*) *okinawensis* (Alexander), the only other regional species with similarly patterned legs.

The following notes of occurrence by Mr. McGregor are of unusual interest: "Hanging from a spider line by fore feet, in light forest." and "On horizontal line of spider web—same habitat as *Limonia* (*Thrypticomyia*) *arachnophila* Alexander and other members of the subgenus, at Lucban. Only three or

four seen here, in rather light hillside forest, away from any stream." The great value in the above observations lies in the fact that they are the first concerning this habit in any member of the subgenus *Euglochina*. Doleschall, in 1857, described as a doubtful member of the genus *Limnobia*, a species that he called *saltens*, that had the habit of hanging on horizontal strands of spider's webs. The arguments that have been made to settle whether the species was a *Thrypticomyia* or a *Euglochina* have been discussed by the writer.[3] The above notes by Mr. McGregor and a study of a copy of Doleschall's figure of *saltens* sent me by Mr. Edwards have convinced me that *saltens* certainly pertains to the subgenus *Euglochina*, as long contended by Mr. Edwards. In the light of our present knowledge of the fact that there are numerous, closely allied species of *Euglochina* in the Oriental and Ethiopian Regions, it would be very unwise to attempt to place *L. cuneiformis* de Meijere as a synonym of *saltens* without an examination of the type of the latter, if it is still extant.

LIMONIA (PSEUDOGLOCHINA) RIUKIUENSIS sp. nov.

Mesonotum dark brown, the præscutum yellowish in front; tibiæ snowy white, with two narrow brownish black rings; wings grayish, the stigma dark brown; Rs relatively long, angulated at origin; vein 2d A unusually long, exceeding the distal section of R_{4+5}; abdominal tergites dark brown, the basal segments with a yellowish median line; sternites yellow, segments four to seven, broadly dark brown at base.

Male.—Length, about 7 millimeters; wing, 6.5.

Female.—Length, about 7 to 7.5 millimeters; wing, 6.5.

Rostrum, palpi, and antennæ black. Head yellow.

Pronotum yellow. Mesonotal præscutum yellow in front and on the humeral region, the remainder dark brown; remainder of the mesonotum dark, paler medially. Pleura yellow, the sternopleurite extensively dark brown. Halteres infuscated. Legs with the fore coxæ and trochanters dark brown, the remaining coxæ and trochanters yellow; femora yellow, the tips infuscated, more broadly so on the posterior legs; tibiæ snowy white, including the setæ, the two rings brownish black, the first placed at near one-fourth the length of the segment, the second just beyond midlength; tarsi snowy white. Wings (Plate 1, fig. 13) with the ground color grayish, the costal region a little darker;

[3] Philip. Journ. Sci. 33 (1927) 299.

stigma dark brown, long-oval, the proximal end sometimes more pointed; a very narrow brown seam at origin of Rs; veins dark brown. Venation: Sc_1 ending beyond midlength of Rs, Sc_2 opposite or just beyond the origin of Rs; Rs elongate and angularly bent near origin; petiole of cell 2d M_2 nearly one-half the cell; vein 2d A of unusual length for a member of this subgenus, on basal fifth approximating the margin, thence swinging cephalad, the cell relatively long and wide, the vein beyond the anal crossvein fully one-fourth longer than the distal section of R_{4+5}.

Abdominal tergites dark brown, the basal segments with a narrow continuous yellow median vitta; incisures and lateral margins pale; sternites extensively pale yellow, the bases of segments four to seven broadly dark brown.

Habitat.—Japan (Riukiu Islands).

Holotype, male, Shuri, Okinawa, altitude about 300 feet, March 8, 1923 (*S. Sakaguchi*). Allotopotype, female. Paratopotypes, 3 females.

Closely allied to *L.* (*P.*) *bicinctipes* (Brunetti) differing in the larger size and details of coloration of the wings and abdomen. Vein 2d A is of unusual length for a member of *Pseudoglochina*.

LIMONIA (PSEUDOGLOCHINA) UNICINCTIPES sp. nov.

General coloration of mesonotum dark brown, the median area behind yellowish; all tibiæ white with a single narrow brownish black ring at near midlength; wing nearly hyaline, the stigma conspicuous, short-oval, dark brown; vein 2d A short, approximately three-fifths to two-thirds the length of the distal section of R_{4+5}; abdominal sternites uniformly pale.

Male.—Length, about 4.4 millimeters; wing, 4.7.

Female.—Length, about 5 millimeters; wing, 5.2.

Rostrum and palpi dark. Antennæ black throughout. Head pale, darker on posterior vertex, the latter area narrowly divided by a pale line.

Mesonotum dark brown, paler on the posterior portion of the præscutum, this color increasing in amount behind, on the scutellum and postnotal mediotergite including the entire sclerite except laterally. Pleura yellow, the sternopleurite darker. Halteres darkened. Legs with the coxæ pale yellow, including the fore coxæ; trochanters dark; femora slightly darkened basally, the posterior femora broadly infuscated, the fore and middle more narrowly so; tibiæ snowy white with a very narrow brownish black ring at near midlength; tarsi snowy white. Wings

(Plate 1, fig. 14) nearly hyaline, the stigma small, short-oval, dark brown; veins black. Venation: Sc_1 ending beyond mid-length of Rs, Sc_2 opposite this origin; Rs short, a little exceeding the basal deflection of R_{4+5}; m-cu at fork of M; vein 2d A short, the basal third approximating the anal margin and parallel with it, the remainder arched and thence extending straight to the margin, the entire vein beyond the anal crossvein from three-fifths to two-thirds the distal section of R_{4+5}.

Abdominal tergites brown, the basal two segments paler medially; sternites more uniformly pale brownish yellow. In the male the tergites are more darkened laterally at base, the median and caudal portions extensively pale.

Habitat.—Philippines.

Holotype, male, Badajoz, Tablas Island, Romblon Province, August 20, 1928 (*Francisco Rivera and A. C. Duyag*). Allotopotype, female.

In the single narrow dark tibial ring, *Limonia unicinctipes* agrees most closely with the larger *L.* (*P.*) *kobusi* (de Meijere) and *L.* (*P.*) *pulchripes* (Alexander). It is difficult to know how accurate is the figure given by de Meijere[4] of the wing of *L. kobusi.* The features shown of a very short petiole to cell 2d M_2 and the position of m-cu at nearly its own length beyond the fork of M are distinctive. From *L. pulchripes* the present species differs in the short Sc_1, the more oblique alignment of the elements of the anterior cord, together with the shorter Rs and the much shorter and more-arcuated vein 2d A.

HELIUS (HELIUS) TENUISTYLUS sp. nov.

General coloration of mesonotum dark brown, the pleura more chestnut brown; rostrum black; legs dark brown, the tarsi paling to yellow; wings with a faint brownish tinge, the stigma and costal margin slightly darkened; R_{2+3} long, diverging gently from R_{4+5}; m-cu at the fork of M; male hypopygium with the dististyles long and slender.

Male.—Length, excluding rostrum, about 5.5 to 6.5 millimeters; wing, 6.5 to 8; rostrum, 0.7 to 0.8.

Female.—Length, excluding rostrum, about 9 millimeters; wing, 8; rostrum, 0.8 to 0.9.

Rostrum black. Antennæ black, the outer segments more attenuated and slightly paler. Head black.

Pronotum black medially above, paler laterally. Mesonotum dark brown, the humeral and lateral regions of the præscutum

[4] Bijd. tot de Dierkunde 18 (1904) pl. 8, fig. 5.

brighter brown; extreme posteromedian region of præscutum and median portion of scutum more yellowish; remainder of notum dark brown. Pleura chestnut brown, the dorsopleural region darker. Halteres dark brown, the base of the stem narrowly yellow. Legs with the coxæ and trochanters brownish yellow; remainder of legs dark brown, the tarsi paling to yellow. Wings (Plate 1, fig. 15) with a faint brownish tinge, the stigma and costal region a little darkened; veins brownish black. Venation: R_{2+3} long, gently sinuous, diverging gently from R_{4+5}; cell 1st M_2 widest at base; m a little longer and more oblique than the basal section of M_3; m-cu at fork of M.

Abdomen brownish black. Male hypopygium (Plate 3, fig. 35) with the dististyles long and slender, the outer style, *od*, chitinized, the apex obtuse; inner style, *id*, longer, subangularly bent. Mesal face of basistyle, *b*, produced into a weakly spinous lobe.

Habitat.—Formosa.

Holotype, male, Kirakei, altitude 4,000 feet, June, 28, 1927 (*S. T. Issiki*). Allotype, female, Chipon, July 4, 1928 (*S. T. Issiki*); paratypes, 3 males, with the allotype.

Helius tenuistylus belongs to a group of closely allied forms that center about *H. nigriceps* (Edwards). The species differs from *H. nigriceps* in the longer, more gently sinuous R_{2+3} and the structure of the male hypopygium.

HELIUS (HELIUS) ATTENUATUS sp. nov.

General coloration of thorax brownish black, the pleura more brownish yellow; rostrum black; legs brownish black, the tarsi paling to brownish yellow; wings with a dusky tinge, the stigma and costal region darker brown; Sc long, Sc_2 ending opposite or beyond the fork of M; R_{2+3} long, gently sinuous; m-cu at fork of M; male hypopygium with the outer dististyle truncated to weakly bidentate at apex; inner dististyle prolonged into a slender yellowish apical portion.

Male.—Length, excluding rostrum, about 5.5 millimeters; wing, 5.5 to 5.8; rostrum, about 0.5.

Female.—Length, excluding rostrum, about 6 millimeters; wing, 5.5; rostrum, about 0.5 to 0.6.

Rostrum dark brown, palpi black. Antennæ black throughout; basal four flagellar segments larger, the remainder narrowed. Head black, the front more opaque and slightly grayish.

Pronotum and mesonotum brownish black, the median area of the scutum paler. Pleura brownish yellow, the dorsopleural

region dusky. Halteres dusky, the base of the stem very restrictedly paler. Legs with the coxæ and trochanters brownish yellow; femora and tibiæ brownish black, the tarsi paling to brownish yellow. Wings with a strong dusky tinge, the stigma and costal region darker brown; wing apex and a seam along vein Cu vaguely infumed; veins dark brown. Venation: Sc long, Sc_2 ending opposite or shortly beyond the fork of Rs, longer than Sc_1; R_{2+3} long and gently sinuous; cell 1st M_2 generally parallel-sided, the proximal end not or but slightly widened; m-cu at fork of M.

Abdomen, including the hypopygium, black. Male hypopygium (Plate 3, fig. 36) with the outer dististyle, *od,* much shorter than the inner, the apex irregularly truncate to weakly bidentate, in the latter case, the inner tooth more acute. Inner dististyle, *id,* long, the apical portion elongate, pale yellow; base of style with numerous setæ, including a fringe of four or five major bristles along the mesal edge. Basistyle, *b,* without a lobe.

Habitat.—Formosa.

Holotype, male, Chipon, July 4, 1927 (*S. T. Issiki*). Allotopotype, female. Paratopotypes, 3 males.

Helius attenuatus is closely allied to *H. nigriceps* (Edwards), differing especially in the darker coloration of the thorax and wings, the details of venation, as the long R_{2+3}, and the details of the male hypopygium, as the very long apical portion of the inner dististyle.

HEXATOMINI

PHYLLOLABIS BEESONI sp. nov.

General coloration pale testaceous yellow; legs pale yellow, the terminal tarsal segments darkened; wings with a pale brownish yellow suffusion, the base and costal region clearer yellow; cell 1st M_2 closed, m-cu at the fork of M_{3+4}; abdomen dark brown, the genitalia brighter.

Female.—Length, about 6.5 to 7 millimeters; wing, 7.2 to 8.

Rostrum pale, the palpi brown. Antennæ of moderate length, if bent backward extending to shortly beyond the base of the halteres; antennæ pale, only the outer segments a trifle darker; flagellar segments elongate, a little enlarged at bases. Head light grayish brown.

Pronotum and mesonotum testaceous yellow, the pleura a litle more yellowish. Halteres pale, the knobs a trifle darker. Legs pale yellow, the terminal tarsal segments darkened. Wings

(Plate 1, fig. 16) with a pale brownish yellow suffusion, the base and costal region clearer yellow, veins brown, the prearcular and costal veins brighter. Venation: Cell 1st M_2 closed; m-cu at the extreme outer end of the cell, opposite the fork of M_{2+4}.

Abdomen dark brown, the genital segment and ovipositor yellowish horn-color; tergal valves of ovipositor elongate and only gently upcurved.

Habitat.—British India.

Holotype, female, Mussoorie, Himalayas, altitude 6,500 feet, August, 1927 (*C. F. C. Beeson*). Paratopotype, female.

I take great pleasure in naming this interesting crane fly in honor of the collector, the Forest Entomologist, Dr. C. F. C. Beeson. *Phyllolabis beesoni* is very different from the only other known Himalayan member of the genus, *P. confluenta* Alexander.[5]

LIMNOPHILA AINO sp. nov.

Male.—Length, about 5.8 to 6 millimeters; wing, 6 to 6.5.

Closely allied to *L. dicranophragmoides* Alexander (Riukiu Islands), differing chiefly in the arrangement of the color pattern.

Antennæ with the first segment of scape black, the second obscure brownish yellow; flagellum chiefly yellow, the outer segments a little darkened. Mesonotal præscutum grayish brown, the three usual stripes entire, the median stripe wide, narrowly divided by a more grayish median vitta; lateral stripes narrow; pseudosutural foveæ and tuberculate pits black, conspicuous, the latter some distance back of the cephalic margin of the sclerite; centers of scutal lobes and the median area brown, yellowish pollinose; scutellum and postnotum brown. Pleura chiefly dark brown. Halteres yellow, the knobs conspicuously dark brown. Legs with the coxæ dark brown; remainder of legs yellow, the outer tarsal segments more infuscated; legs with conspicuous semierect pale setæ. Wings with the ground-color more whitish subhyaline, the pattern arranged in similar manner to *L. dicranophragmoides* but the individual bands more separated, especially the one at origin of Rs and the one along the cord; the latter two are separated by a wide, generally clear band that is approximately as wide as the first-mentioned dark band; dark bands of wing more compact, the pale spots and dashes within them being much reduced; along the costal margin the four or five

[5] Rec. Indian Mus. 29 (1927) 206–207, fig. 17.

outer areas are solidly darkened, not with a pale central spot as in *L. dicranophragmoides.* Venation: Sc short, Sc_1 ending opposite or shortly before the fork of Rs; inner ends of cells R_4, R_5, and 1st M_2 in oblique alignment, the last most basad; m-cu not far beyond the fork of M. Abdomen chiefly brown, the tergites darker laterally; a narrow subterminal dark ring; hypopygium reddish brown; basal sternites more reddish brown, darkened laterally and caudally, the outer segments more uniformly darkened. Male hypopygium (Plate 3, fig. 37) with the outer dististyle, *od,* appearing as a blackened rod, the tip strongly curved into a spine, the outer margin quite smooth, the inner margin, in the axil of the terminal spine, with a few microscopic denticles. Inner dististyle, *id,* very broad, mitten-shaped. Gonapophyses, *g,* appearing as pale rods, the apex of each dilated into an oval head.

Habitat.—Japan (Hokkaido).

Holotype, male, Jozankei, altitude about 1,000 feet, July 29, 1923 (*S. Kuwayama*). Paratopotypes, 9 males, mostly in poor condition.

ERIOPTERINI

CLADURA ALPICOLA sp. nov.

General coloration pale yellow; legs yellow, the extreme tips of the femora and tibiæ infuscated; tarsi extensively brownish black; wings pale yellow; a tiny black spot at extreme base of wing; male hypopygium large and complex, the basistyle with a large mesal lobe that is unequally bilobulate near tip; inner dististyle with a conspicuous basal shoulder.

Male.—Length, 7.5 to 8 millimeters; wing, 8.5 to 9.

Head, thorax, and abdomen with long conspicuous pale setæ. Rostrum brownish yellow, palpi darker. Antennæ with the basal segment dark brown, in some cases so colored only basally, the remainder yellowish; outer flagellar segments darker; verticils elongate. Head pale brownish yellow, more rarely darker, grayish brown.

General coloration of prothorax and mesothorax pale yellow, immaculate. Halteres pale, the knobs weakly darkened. Legs with the coxæ and trochanters pale yellow; femora yellow, the extreme tips infuscated, tibiæ yellow, the tips narrowly darkened; tarsi extensively brownish black; legs conspicuously hairy. Wings (Plate 1, fig. 17) pale yellowish; a single tiny black dot at extreme wing base above the squama; veins brown, the prearcular and costal veins more yellowish. Macrotrichia of veins long

and conspicuous. Venation: Sc_1 relatively short, only a little longer than Sc_2; Rs long, gently arcuated; R_{2+3+4} shorter than cell 1st M_2; petiole of cell M_1 subequal to or considerably exceeding m; m-cu from one-half to nearly its own length beyond the fork of M; vein 2d A long, very gently sinuous.

Abdomen yellow, the tergites with narrow, interrupted median and lateral dusky stripes, in cases including the subcaudal portions of the segments; sternites similar, their caudal margins darkened; hypopygium pale. Male hypopygium (Plate 3, fig. 38) very large and complicated in structure, much as in *C. megacauda*, differing especially in the structure of the tergite, basistyle, and dististyle. Basistyle, *b*, with the mesal lobe large, flattened, at apex somewhat expanded, on outer margin before apex with a small fingerlike lobe terminating in a small pencil of setæ. Outer dististyle, *od*, very long and pale, slender, considerably longer than the inner style, setiferous, with larger setæ at apex. Inner dististyle, *id*, distinctly bilobed, there being a stout basal shoulder, the more slender inner arm truncate at apex. Gonapophyses, *g*, taken together appearing lyriform, relatively slender, the obliquely truncated apex weakly toothed.

Habitat.—Japan (Honshiu).

Holotype, male, Yarigatake, Japanese Alps, August 24, 1925 (*Jiro Machida*). Paratopotypes, 4 males; paratypes, 3 males, Tsubakuro, Japanese Alps, August 23, 1925 (*Jiro Machida*).

Claudura alpicola is most closely allied to *C. megacauda* Alexander (Hokkaido, Japan), differing especially in the details of structure of the male hypopygium. These two species belong to a distinct group of the genus that can scarcely be referred to the subgenus *Neocladura* Alexander, the only other division of the genus in which the male hypopygium possesses two dististyles.

GYMNASTES CATAGRAPHA sp. nov.

? *Teucholabis* sp. nov. BRUNETTI, Rec. Indian Mus. **15** (1918) 306.

Head orange; mesonotum yellowish, the præscutum with a median black stripe; knobs of halteres orange-yellow; femora with a yellow subterminal ring; wings whitish subhyaline, with three brown crossbands; abdominal tergites dimidiate orange and dark brown.

Male.—Length, about 6.5 millimeters; wing, 5.7.

Rostrum shiny reddish yellow; palpi brownish black. Antennæ with the basal segment orange; second segment brown, paler at base; flagellum brownish black; flagellar segments elongate-

oval to subcylindrical, with elongate verticils. Head broad, obscure orange.

Pronotum obscure orange-yellow. Mesonotal præscutum yellow, the median stripe shiny black, the lateral stripes reddish, poorly delimited; scutum shiny yellow medially, each lobe with a blackened spot near mesal portion, the remainder reddish; scutellum brownish black, brighter basally; postnotum blackened, paler laterally. Pleura badly injured by the pin, the propleura reddish brown, the mesopleura apparently darker brown, variegated with paler. Halteres dusky, the knobs orange-yellow. Legs with the coxæ and trochanters reddish yellow; femora obscure yellow, the distal half passing into dark brown, with a conspicuous subterminal yellow ring that is a little narrower than the darkened tip; tibiæ brown, becoming darker brown toward the tip; tarsi brown, the distal segments darker. Wings (Plate 1, fig. 18) whitish subhyaline, the prearcular and costal region more yellowish; a heavy brown pattern, appearing as three crossbands; basal band narrow, almost parallel-sided, extending from R at the origin of Rs to the anal margin at the end of vein 2d A, very narrowly interrupted in cell R adjoining vein M; the second band includes the cord, widened out at the stigmal region, narrower along the cord, again widened out but much paler in the outer end of cell Cu; the third band includes the wing-tip in cells R_3, R_4, R_5 2d M_2, and M_3, the inner margin nearly straight; a broad additional seam at the outer end of cell 1st M_2; veins pale brown, a little darker in the infuscated areas. Venation: Sc_1 ending shortly before the fork of Rs, Sc_2 some distance from the tip of Sc_1; R_{2+3+4} a little longer than R_2 alone; R_{2+3} punctiform; R_2 directed a little basad, about one-half R_{1+2}; veins R_3 and R_4 widely divergent, the former about one-half the latter; cells R_4, R_5, and 1st M_2 in slightly oblique alignment; cell 1st M_2 rectangular, a little widened outwardly; m-cu less than its length beyond the fork of M.

Abdominal tergites conspicuously dimidiate, the basal two-thirds of each segment dark brown, the remainder orange; sternites similar but the dimidiate appearance not so conspicuous, especially on the basal segments where the ground color is pale brown, the incisures broadly orange; on the subterminal segments the colors are more contrasted; hypopygium obscure fulvous; no sternal pouch. Male hypopygium (Plate 3, fig. 39) very small; caudal margin of the tergite convex. Basistyle, *b*, rela-

tively large, the outer angle produced, the dististyles being placed on the mesal face of the style at near midlength; two small blackened combs on the style. Outer dististyle a flattened blade, the outer angle at base darkened and microscopically roughened; apex obtuse, darkened, sparsely setiferous, the margin with microscopic serrulations. Inner dististyle smaller, the margins smooth, before the apex with a powerful bristle. Ædeagus, *a*, very large, appearing as a conspicuous pale blade that juts caudad beyond the other elements of the hypopygium, the apex obtuse but extended into a short point on the ventroapical portion; distal portion of ædeagus with conspicuous setæ.

Habitat.—Southwest India.

Holotype, male, Castle Rock, North Canara District, October 11 to 26, 1916 (*S. Kemp*). Type in the collection of the Indian Museum.

Gymnastes catagrapha is allied to *G. demeijerei* (Riedel),[6] differing in the chiefly yellow body coloration, as well as in the differently colored halteres and legs.

STYRINGOMYIA TABLASENSIS sp. nov.

General coloration yellow, variegated with brownish black; head gray; femoral dark rings incomplete; wings yellow, with four separate dark areas; vein 2d A simple, the apex gently curved; male hypopygium with the ninth sternite deeply bilobed at apex; outer arm of dististyle a long rod that narrows gradually to the acute simple apex.

Male.—Length, about 4 millimeters; wing, 4.2.

Antennal scape dark, the flagellum conspicuously paler. Head gray.

Pronotum brownish black, narrowly paler medially; posterior notum paler laterally. Mesonotal præscutum with the median portion brownish black, the posterior two-thirds fulvous-yellow with a sinuous black line on either side of the more cinerous median area; scutal lobes and median area chiefly pale, completely margined laterally and caudally with black; scutellum black, the median area restrictedly pale; postnotal mediotergite brownish black. Pleura pale, yellowish, the color including the pleurotergite. Halteres pale yellow. Legs with the coxæ and trochanters yellow; femora yellow with two narrow incomplete dark rings, as usual in the genus, the ventral surface of the femora immaculate; tibiæ yellow, the tips darkened; tarsi yellow,

[6] Ann. Mus. Nat. Hung. 18 (1921) 135–136, new name for *Gnophomyia fascipennis* de Meijere, Bijd. tot de Dierkunde 21 (1919) 15, preoccupied.

the last segment black. Wings with a yellowish suffusion; four dark brown areas, as follows: A large oval area centering about r-m, including the extreme bases of the adjoining veins; fusion of M_{2+1} and M_3; m-cu; distal third of vein 2d A; veins yellow, brownish black in the infuscated areas. Venation: A short fusion of M_3 with M_{1+2} beyond cell 1st M_2; vein 2d A gently curved to the margin.

Abdominal tergites yellow, each segment with two brown spots at caudal margin, on the seventh segment becoming larger and confluent; eighth segment with a longitudinal brown median stripe; hypopygium chiefly pale; sternites more uniformly pale yellow. Male hypopygium (Plate 3, fig. 40) with the ninth tergite, *9t*, a broad pale setiferous lobe, the apex very insensibly bilobed. Ninth sternite, *9s*, very deeply bilobed, each lobe bearing a very long seta. Basistyle, *b*, with the outer apical angle a slender pale lobe that bears a slender seta that is longer than the lobe itself. Dististyle, *d*, very complex, the outer arm a long rod, its base wide and pale, the outer end narrowed to the acute gently curved apex, entirely without a long apical seta, as in many species of the genus. Two arms, gently curved and more or less opposed to one another, bearing series of peglike spines, those of the outer arm (about 15) more crowded, of the inner or cephalic arm (about 9) more scattered; other lobes of the complex dististyle include a simple boomerang-shaped structure and a broad-based lobe that is tipped with one or two powerful black spines and bears a long powerful seta before apex.

Habitat.—Philippines.

Holotype, male, Badajoz, Tablas Island, Romblon Province, August 27, 1928 (*Francisco Rivera and A. C. Duyag*).

STYRINGOMYIA NIPPONENSIS sp. nov.

Male.—Length, about 5.5 millimeters; wing, 5.2.

Closely allied to *S. formosana* Edwards, differing especially in the structure of the dististyle of the male hypopygium.

Second segment of scape dark brown, the base paler. Largest setæ of head black, a few smaller ones yellow. Menosotal præscutum dark brown, with longitudinal paler stripes, the dark areas of the interspaces interrupted at the level of the pseudosutural foveæ; posterior median region of præscutum, median area of scutum, and central portion of scutellum yellow, scutal lobes reddish brown, encircled by darker, each with an erect seta near mesal edge; disk of scutellum with an erect seta on each side of the yellowish median area; postnotum darkened. Pleura

pale yellow. Halteres pale, the knobs weakly infuscated. Legs with the dark areas on femora narrow and restricted to the dorsal portion; medial tibial ring similarly incomplete, the apical ring narrow but entire; basal four tarsal segments almost white, incisures weakly darkened; terminal segment black. Wings with a yellowish suffusion, the base and costal region brighter; a circular dark spot on r-m; less distinct dark seams on m-cu, outer end of cell 1st M_2 and distal third of 2d A; medial veins beyond cord chiefly darkened; radial, costal, and cubital veins pale. Venation: R_{2+3+4} oblique; m-cu nearly its own length beyond fork of M; vein 2d A bent strongly at end, subangulate but unspurred. Abdominal tergites obscure yellow; basal segment dark; succeeding segments with paired dark spots on caudal margins and less distinct ones on basal ring of segment; segment 7 with a median darkening; hypopygium chiefly pale. Male hypopygium with the dorsal apical lobe of basistyle with a longer and more hairlike apical bristle. Dististyle with the outer lobe long and slender, the apical seta long, as in *formosana;* anterior lobes of dististyle (Plate 3, fig. 41) broad at base, one narrowed apically into an acute pale point, the apical margin with two or three groups of blackened pegs, the more proximal of these arranged more or less in the form of a crescent; innermost lobe of dististyle with the apex obtuse, the outer caudal angle with numerous black peglike spines that decrease in size and become more separated outwardly; surface of style basad of these pegs with very long, basally directed setæ. Ninth sternite very narrow, entire, with the usual two apical setæ.

Habitat.—Japan (Honshou).

Holotype, male, Asahara, June 1, 1925 (*C. Harukawa*).

It may be noted that *Styringomyia formosana* Edwards has been taken as far north as Tokyo (May 14, 1919, *R. Takahashi*) and is thus the most northerly record for the genus.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapopyhysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Brithura sancta* sp. nov., wing.
2. *Brithura conifrons* Edwards, wing.
3. *Tipula rantaicola* sp. nov., wing.
4. *Tipula microcellula* Alexander, wing.
5. *Nesopeza rantaizana* sp. nov., wing.
6. *Oropeza bispinula* sp. nov., wing.
7. *Limonia* (*Limonia*) *rantaiensis* sp. nov., wing.
8. *Limonia* (*Dicranomyia*) *tristoides* sp. nov., wing.
9. *Limonia* (*Geranomyia*) *suensoniana* sp. nov., wing.
10. *Limonia* (*Alexandriaria*) *argyrata* sp. nov., wing.
11. *Limonia* (*Thrypticomyia*) *brevicuspis* sp. nov., wing.
12. *Limonia* (*Euglochina*) *arachnobia* sp. nov., wing.
13. *Limonia* (*Pseudoglochina*) *riukiuensis* sp. nov., wing.
14. *Limonia* (*Pseudoglochina*) *unicinctipes* sp. nov., wing.
15. *Helius* (*Helius*) *tenuistylus* sp. nov., wing.
16. *Phyllolabis beesoni* sp. nov., wing.
17. *Cladura alpicola* sp. nov., wing.
18. *Gymnastes catagrapha* sp. nov., wing.

PLATE 2

FIG. 19. *Brithura sancta* sp. nov., male hypopygium.
20. *Tipula subfutilis* sp. nov., male hypopygium.
21. *Tipula subfutilis* sp. nov., male hypopygium, ninth tergite.
22. *Tipula futilis* Alexander, male hypopygium, ninth tergite.
23. *Tipula futilis* Alexander, male hypopygium.
24. *Tipula yusouoides* sp. nov., male hypopygium.
25. *Tipula subyusou* sp. nov., male hypopygium, gonapophysis.
26. *Tipula yusou* Alexander, male hypopygium, gonapophysis.
27. *Nesopeza idiophallus* sp. nov., male hypopygium, ædeagus.
28. *Oropeza satsuma* Alexander, male hypopygium.
29. *Oropeza satsuma* Alexander, male hypopygium, ninth tergite.
30. *Oropeza bispinula* sp. nov., male hypopygium.
31. *Oropeza bispinula* sp. nov., male hypopygium, ninth tergite.
32. *Limonia* (*Dicranomyia*) *tristoides* sp. nov., male hypopygium.

PLATE 3

FIG. 33. *Limonia* (*Geranomyia*) *tenuispinosa* sp. nov., male hypopygium.
34. *Limonia* (*Thrypticomyia*) *brevicuspis* sp. nov., male hypopygium.

FIG. 35. *Helius* (*Helius*) *tenuistylus* sp. nov., male hypopygium.
36. *Helius* (*Helius*) *attenuatus* sp. nov., male hypopygium.
37. *Limnophila aino* sp. nov., male hypopygium.
38. *Cladura alpicola* sp. nov., male hypopygium.
39. *Gymnastes catagrapha* sp. nov., male hypopygium.
40. *Styringomyia tablasensis* sp. nov., male hypopygium.
41. *Styringomyia nipponensis* sp. nov., male hypopygium, diststyles.

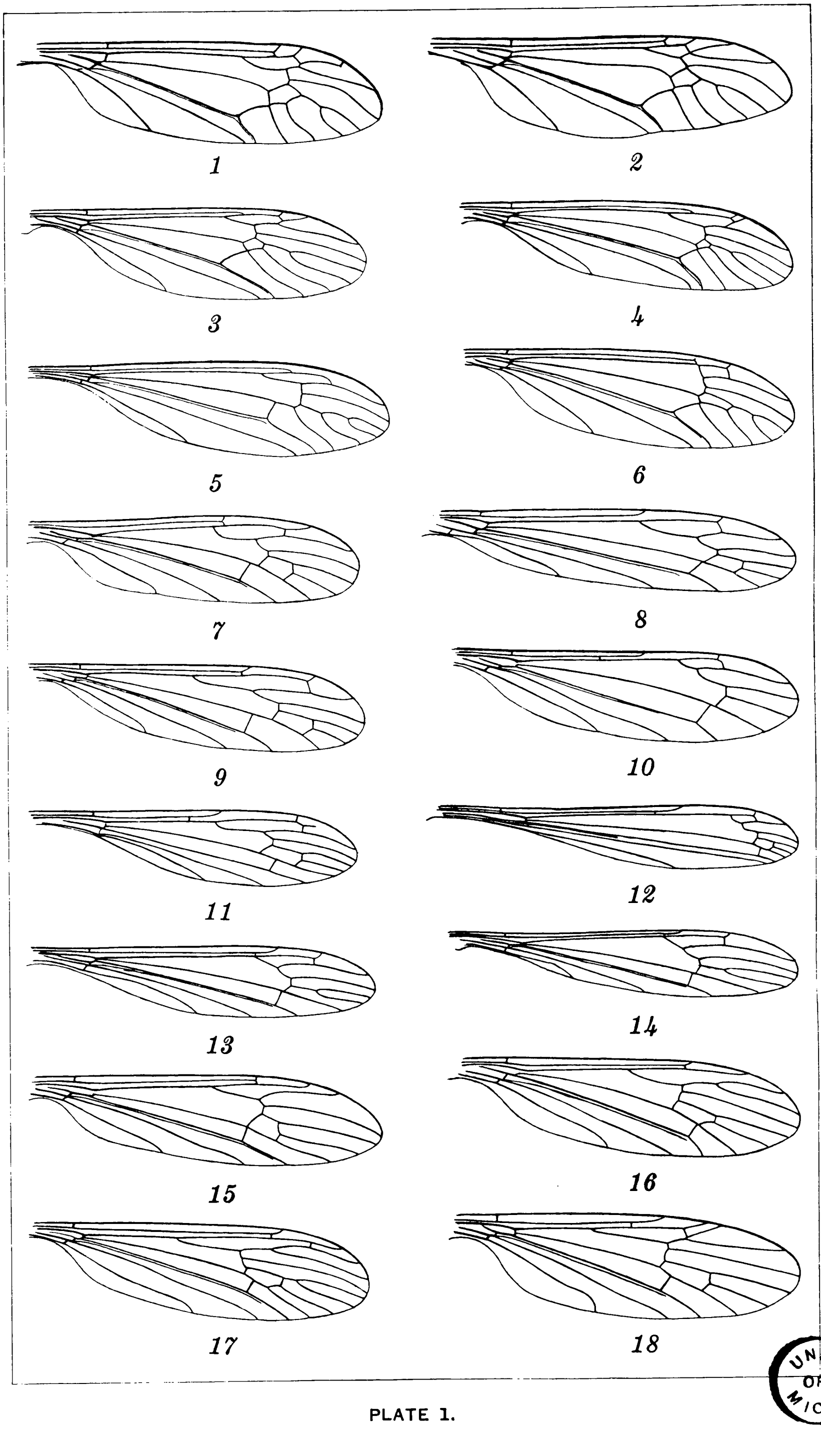

PLATE 1.

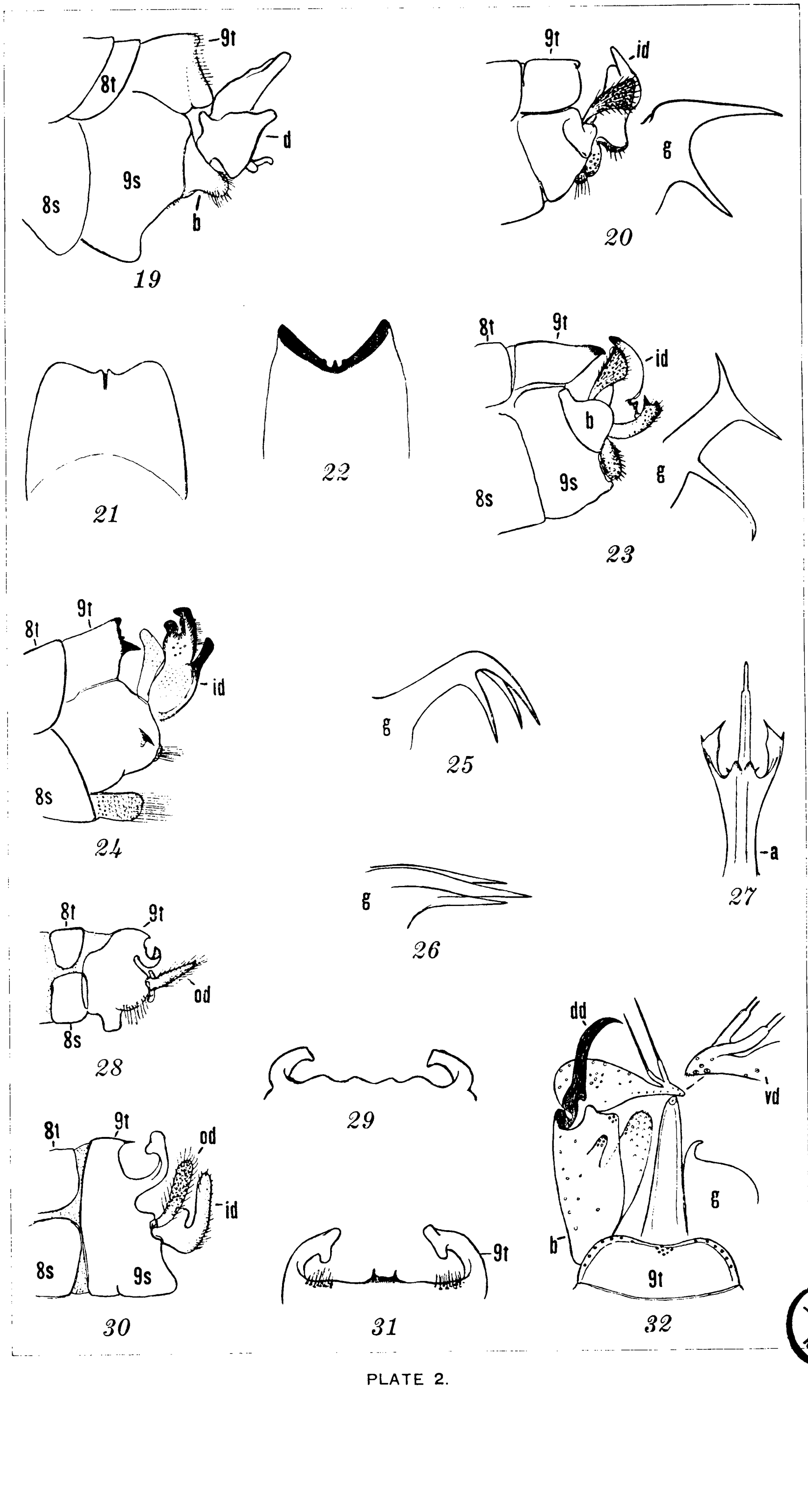
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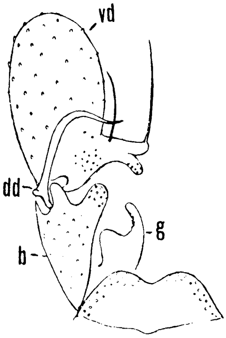
PLATE 2.



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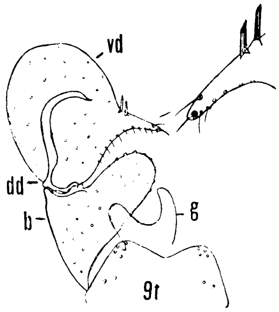

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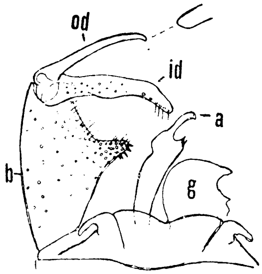

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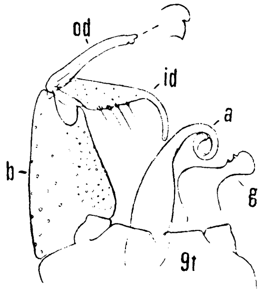

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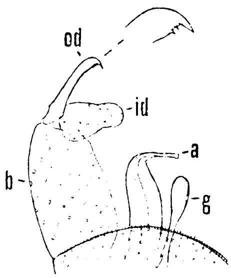

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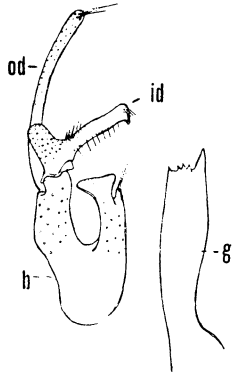

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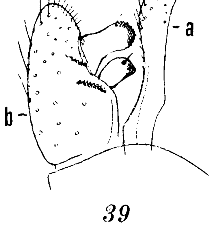

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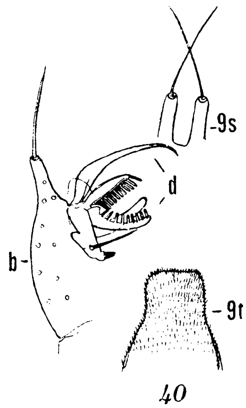

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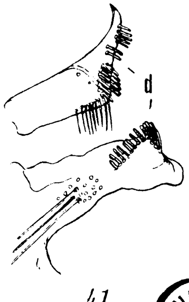

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PLATE 3.

COMPOSITION OF PHILIPPINE COFFEE

By ABELARDO VALENZUELA

Of the Bureau of Science, Manila

Some years ago the growing of coffee in the Philippines was an important and promising industry. At one time there was an average annual export of about 7,000 tons [1] of coffee valued at 4,000,000 pesos. The advent of the coffee blight, *Hemileia vastatrix*, practically destroyed the coffee industry. In 1913, the Philippines produced only 113,031 kilograms of coffee. In 1927 the export of Philippine coffee was only 96 kilograms, while the total imports were valued at 1,714,595 pesos.[2] Formerly the Arabian coffee was the principal species cultivated in the Philippines. This species of coffee suffered so severely from the coffee blight that it would seem advisable in starting new plantations to use a more resistant species such as Robusta, Liberica, or Excelsa. These coffees seem to be satisfactory substitutes for the Arabian species; and although they are not immune to the blight, they are so resistant that notwithstanding the presence of the blight they grow well and produce abundant crops. Again, these coffees thrive under more varied conditions than the Arabian coffee. In Java, where the Robusta coffee is planted very extensively, permanent shade is considered advisable. Some of the shade trees considered suitable for coffee are the ipil-ipil, which is the best, and the madre de cacao, dapdap, and guango. A good account of the agriculture of Robusta and other species of coffee is given by Wester [3] and also by David and Baker.[4]

The samples of Philippine coffee used in this investigation were obtained from the Philippine Bureau of Agriculture. Seven species were analyzed. They were the Robusta, *Coffea robusta* Linn.; Liberica, *Coffea liberica* Hiern; Canephora, *Coffea canephora* Pierre; Abeota, *Coffea abeocuta* Cr.; Excelsa, *Coffea excelsa* A. Chev.; Uganda, *Coffea ugandæ* Cr.; and Arabian,

[1] Wester, P. J., Philip. Agr. Rev. **8** (1915) 39.

[2] Annual Report, Insular Collector of Customs, Manila (1927).

[3] Philip. Agr. Rev. (1918) 129.

[4] Philip. Agr. Rev 17 (1928) 65.

Coffea arabica Linn. A brief description of these coffees and the trees from which they are obtained is given by Wester.[5]

Coffea robusta is a small tree which is adapted to a reasonably friable and fertile soil. It requires abundant rain, and grows best at altitudes ranging from 450 to 700 meters. It yields from 875 to 1,800 kilograms of coffee per hectare, but the coffee requires artificial drying. *Coffea canephora* and *Coffea ugandæ* are closely related to Robusta and have similar requirements.

Coffea liberica is a small tree adapted to elevations of 350 meters or less. It succeeds well on rather heavy, clayey soils and yields about 650 kilograms of coffee per hectare. When properly prepared, the coffee is of good quality. *Coffea abeocuta* and *Coffea excelsa* have requirements similar to Liberica to which they are closely related. However, Abeota, and Excelsa coffees yield berries much smaller than those of Liberica.

Coffea arabica is common throughout the Philippines, but of no importance except in the highlands of Mindanao and northern Luzon, and even there the production is limited owing to the coffee blight.

In Table 1 is given the composition of various Philippine raw coffees. In anayzing these coffees the usual standard methods of analysis were employed.[6] The caffeine, however, was determined by the modified Stahlschmidt method.[7]

TABLE 1.—*Composition of Philippine raw coffees.*

Constituent.	Robusta.	Liberica.	Canephora.	Abeota.	Excelsa.	Uganda.	Arabian.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8.11	8.18	11.72	8.93	10.49	10.48	11.08
Caffeine	1.79	1.69	2.42	1.74	1.83	2.06	1.62
Fat	9.36	9.69	7.39	9.10	9.54	7.41	8.20
Reducing sugar	4.08	4.75	6.35	6.85	4.55	6.05	3.97
Crude fiber	18.57	17.86	25.80	17.66	22.80	18.38	16.52
Nitrogenous substances	13.70	15.01	11.26	11.96	13.12	12.54	13.00
Ash	4.57	4.09	4.33	3.69	3.47	4.05	4.44
Other non-nitrogenous substances (by difference.)	39.82	38.46	30.73	40.07	34.20	39.03	41.17
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[5] Bull. P. I. Bur. Agr. **39** (1925) 62.

[6] Methods of Analysis of the Association of Official Agricultural Chemists (1924) 333.

[7] Fuller, H. C., Chemistry and Analysis of Drugs and Medicines (1920) 289.

In Table 2 is given the average composition of Philippine and foreign raw coffees.

TABLE 2.—*Composition of Philippine and foreign raw coffees.*

	Philippine coffees.	Foreign coffees. [a]
	Per cent.	*Per cent.*
Moisture	9.86	11.23
Caffeine	1.87	1.21
Fat	8.71	12.27
Reducing sugar	5.22	8.55
Crude fiber	19.65	18.17
Nitrogenous substances	12.95	12.07
Ash	4.10	3.92
Other non-nitrogenous substances (by difference)	37.64	32.58
Total	100.00	100.00

[a] Leach, A. E., Food Inspection and Analysis (1920) 393.

As shown by the data (Table 2) the Philippine raw coffees seem to compare favorably in composition with foreign raw coffees. Raw Philippine coffee contains a slightly higher percentage of caffeine than the foreign raw coffees. The foreign coffee, however, contains a somewhat higher percentage of fat and reducing sugar.

SUMMARY

Seven varieties of Philippine raw coffee were analyzed. The results seem to indicate that in composition Philippine coffees compare favorably with foreign coffees.

EFFECTS OF SPLENECTOMY UPON THE PRODUCTION OF ANTIBODIES IN DOGS

By Hilario Lara and Carmelo Reyes

Conjointly of the Department of Hygiene and Preventive Medicine, and the Departments of Surgery and Gynecology, University of the Philippines, Manila

INTRODUCTION

The function of the spleen has been studied from various angles in the past, but it is only recently that attempts have been made to determine the influence that this organ exerts upon bodily resistance against certain forms of definite harm.

De Boer and Carrol [1] in their carbon monoxide (Co) poisoning experiments suggested that the function of the splenic contraction was to expel unpoisoned red cells into the blood and so reduce the proportion of carbon monoxide hæmoglobin (COHb) to hæmoglobin dioxide (HbO_2) in the general circulation.

Barcroft, Murray, et al.[2] showed that, in an atmosphere which received a continuous accession of coal gas, splenectomized guinea pigs died sooner than either normal guinea pigs, or those from which a piece of the omentum has been removed, or those from which one horn of the uterus has been excised.

Singer [3] in 1925 reported on a breach of natural immunity affected by blockade of the reticulo-endothelial system.

Lewis and Margot [4] in 1914 published descriptions of experiments which seemed to show that splenectomy greatly increased the resistance of albino mice to infection with *Bacillus tuberculosis*, but later Murphy and Ellis [5] were able to explain this seemingly anomalous result. They found that mice splenectomized a short time prior to inoculation with *B. tuberculosis* were distinctly more susceptible than normal animals; while, with the increase of the interval between splenectomy and infection, the mice gradually showed greater resistance than

[1] Journ. Physiol. **59** (1924–1925) 312.
[2] Journ. Physiol. **60** (1925) 79.
[3] Cited by Jungeblutt, Journ. Exp. Med. **46** (1927) 609–613.
[4] Ibid.
[5] Ibid.

the controls. They attributed this increased resistance to a secondary hypertrophy of the remaining lymphoid tissue.

Our experiment is an attempt to determine the effect of the removal of the spleen on the production of agglutinins in the blood stream of experimental animals shortly after recovery from splenectomy operations.

EXPERIMENTS

Operations.—In the experimental work that forms the basis of this paper, twenty-two dogs have been splenectomized, of which the first series of seven was operated on between July 7 and 28, 1925, but were not experimented upon, the animals having developed some kind of skin eruptions (presumably from ticks with which they were afflicted) which it was feared might influence the results. Therefore, it is the second series of dogs (fifteen in all) operated upon between June 16 and July 7, 1928, that has been chiefly depended on for this study.

All of the operations were performed under ether anæsthesia. There was nothing unusual in the technic. The three main branches of the artery in the gastrosplenic omentum were separately ligated previous to the extirpation of the organ and in some cases religated en bloc. After losing an uruly dog (presumably from a secondary postoperative hæmorrhage on the third day) chromicized catgut was substituted for plain catgut in the ligation of the splenic vessels in some of the cases. The same material was used for the skin, as abacá, our local skin-suture material, had not proved strong enough in some of the preceding operations.

Except in the one case no blood was lost; there was no operative difficulty, and the whole procedure averaged a quarter of an hour each time. Stitches were removed on the tenth day, and wounds healed by first intention.

Animal have been splenectomized on an average twenty-two days before preliminary titration, thirteen and twenty-seven days being the extremes; forty-two days to the date of the first injection, August 2; forty-six days to August 6; fifty-one days to August 11; and fifty-seven days to August 17, the date of serum titration.

With the exception of three dogs that refused to eat one or two days before their death, and appeared to become weaker, lying down in their cages most of the time, and having profuse lachrymal secretions which dried up and accumulated about their eyelids, the dogs did not appear to be visibly ill. Two of them appeared to have difficulty of micturition.

The average duration of postoperative life was thirty-six days; the extremes were ten days (exclusive of the dog dying of secondary hæmorrhage) and eighty-seven days.

Of the fifteen splenectomized dogs in our second series fourteen recovered and one died presumably from active secondary hæmorrhage, a large amount of dark fluid blood having been found in its abdominal cavity. Of the fourteen splenectomized dogs that recovered one escaped forty-two days after operation in very strong condition; in fact, it was the liveliest of the group. Of the thirteen that remained for immunization, nine died after the removal of blood for titration prior to immunization.

Of all the animals experimented upon in 1928, second series (fifteen splenectomized and six nonsplenectomized for control), only four splenectomized and four nonsplenectomized lived long enough to have their serums titrated after immunization.

Immunization and titration.—Cholera vaccine (containing 1,000 million killed organisms per cubic centimeter of sterile salt solution), preserved with 0.5 per cent phenol, was used for immunizing the control (nonsplenectomized) and the splenectomized animals. Each dog of the splenectomized and the nonsplenectomized groups, practically at the same time, was given a dose of 0.20 cubic centimeter of the above-mentioned vaccine per kilogram of body weight hypodermically on the side, three times at intervals of from five to six days.

One week after the last dose of the vaccine about 5 cubic centimeters of blood were removed under aseptic precaution from the femoral vein of each dog, and the samples of blood were placed in separate test tubes and allowed to clot. The clots were separated from the sides (aseptically), and the tubes were placed in a refrigerator and allowed to stand overnight. The next day the serum was separated from the clot and $\frac{1}{10}$, $\frac{1}{50}$, $\frac{1}{100}$, $\frac{1}{150}$, $\frac{1}{200}$, $\frac{1}{250}$, $\frac{1}{300}$, $\frac{1}{350}$, $\frac{1}{400}$, $\frac{1}{450}$, $\frac{1}{500}$, $\frac{1}{550}$, $\frac{1}{600}$, and $\frac{1}{650}$ dilutions of each sample were prepared. One-half cubic centimeter of each of these dilutions was placed in a separate sterile serological test tube and an equal amount of saline emulsion of a 24-hour-old culture of cholera vibrio added, the resulting final dilution, therefore, being twice each of those above indicated. The mixture was shaken very thoroughly, incubated for eighteen hours, and the titer read.

TABLE 1.—*Effect of splenectomy upon antibody production in dogs.*

NONSPLENECTOMIZED (NORMAL).

Dog.	Preliminary titer.		Immunized August 2, 1928.		Immunized August 6, 1928.		Immunized August 11, 1928.	
	Date.	Titer.	Body weight.	Dose of vaccine.	Body weight.	Dose of vaccine.	Body weight.	Dose of vaccine.
			Kg.		*Kg.*		*Kg.*	
A	July 31	----------	6.00	1.20	6.10	1.22	5.90	1.18
B	July 31	----------	10.50	2.10	11.30	2.26	10.0	2.00
C	July 31	----------	7.60	1.52	8.35	1.67	7.50	1.500
D	July 31	----------	8.60	1.72	9.05	1.81	9.00	1.800
SPLENECTOMIZED.								
1	July 13	----------	10.35	2.07	10.73	2.14	10.70	2.14
2	July 13	----------	5.45	1.09	5.98	1.19	5.85	1.17
3	July 13	----------	11.70	2.34	12.55	2.51	12.50	2.50
4	July 13	1/50	6.50	1.30	7.25	1.45	6.80	1.36

NONSPLENECTOMIZED (NORMAL).

Dog.	Serum titer August 17, 1928.														Remarks.
	1/20	1/100	1/200	1/300	1/400	1/500	1/600	1/700	1/800	1/900	1/1000	1/1100	1/1200	1/1300	
A	+	+	+	+	+	+	------	------	------	------	------	------	------	------	Died September 20, 1928.
B	+	+	+	+	+	+	+	+	+	+	------	------	------	------	Survived till given away.
C	+	+	+	+	+	------	------	------	------	------	------	------	------	------	Died August 26, 1928.
D	+	+	+	+	+	+	+	+	+	+	+	+	+	------	Died September 18, 1928.
SPLENECTOMIZED.															
1	+	+	+	+	------	------	------	------	------	------	------	------	------	------	Died September 13, 1928.
2	+	+	+	+	------	------	------	------	------	------	------	------	------	------	Died September 4, 1928.
3	+	+	+	+	+	+	±	------	------	------	------	------	------	------	Died September 18, 1928.
4	+	+	+	+	------	------	------	------	------	------	------	------	------	------	Died August 31, 1928.

RESULTS

The results of the experiments from the surviving animals are presented in Table 1. In this table are shown the date when the preliminary titer was made of the blood of the splenectomized and nonsplenectomized dogs prior to immunization; the date and the dose of vaccine administered to the animals at stated intervals; and the titer of the serums after immunization. The data for the rest of the animals used in these experiments are not presented in view of the fact that the animals died before observations useful for our purposes could be made of them.

The titer of the serums of the nonsplenectomized dogs are as follows: Dog A, $\frac{1}{500}$; dog B, $\frac{1}{900}$; dog C, $\frac{1}{400}$; dog D, $\frac{1}{1200}$.

The titer of the serums of the splenectomized dogs are as follows: Dog 1, $\frac{1}{300}$; dog 2, $\frac{1}{300}$; dog 3, $\frac{1}{600}$; dog 4, $\frac{1}{300}$.

CONCLUSIONS

1. Twenty-two dogs were splenectomized, seven in 1925 (first series) and fifteen in 1928 (second series). The second series, with six more nonsplenectomized dogs, constitutes the basis of this report. In this study only four splenectomized and four nonsplenectomized dogs lived long enough to have their serums titrated after immunization.

2. Judging from our limited experience, splenectomy in presumably normal dogs seems to affect unfavorably antibody production (agglutinins) shortly after the immunization.

A GEOLOGICAL STUDY OF THE ANGAT-NOVALICHES REGION

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TWENTY-EIGHT PLATES AND THREE TEXT FIGURES

INTRODUCTION

The study of the geology of the Angat-Novaliches region was undertaken primarily for the purpose of supplying the Metropolitan Water District with geologic cross-sections along the proposed tunnel lines between their Ipo dam site on Angat River and the Novaliches reservoir site in connection with the Angat water system project. A report has already been submitted to the Metropolitan Water District covering briefly such topics as stratigraphy, structure, and general geology, and giving a more-detailed discussion of the points which concern their project from a geologic standpoint.

The present paper is a detailed study of the geology of the region with special emphasis on the structure. The most violent earthquakes have been occasioned by sudden movements or slips between portions of the earth's crust along fault planes. It is necessary to make a detailed study of the structure of a region, with a careful mapping of every fault and a study of its probable directions of movement and activities, in order to find the probable centers and directions of the shocks of future tectonic earthquakes in that region.

At the same time, some important points in Philippine geologic history have been cleared in this paper, since the Angat-Novaliches region is an unusually good representative of Philippine general geology.

FIELD WORK AND ACKNOWLEDGMENTS

The writer, assisted by Ramon F. Abarquez, made three trips. The first one, from March 24 to 28, 1924, was a brief reconnaissance along one of the proposed tunnel lines of the Metropolitan Water District. The second trip was made from September 16 to 22, 1924. Trips were made upstream on Angat River and Ipo River. Outcrops were plentiful and the sections

were studied carefully. While shooting the Angat River rapids on a bamboo raft from the Ipo dam site downstream to Norzagaray, we observed and carefully noted a well-exposed section. This section served to establish a tentative stratigraphic column, which was revised as the work progressed. During the third trip, November 22 to December 20, 1924, the geology, stratigraphy, and structure of the region were studied in detail and all of the formations were mapped as carefully as possible.

Acknowledgment is due the staff of the division of mines, Bureau of Science, for help rendered in symposiums concerning the various problems.

PREVIOUS WORK

Becker [1] in his report on the geology of the Philippine Islands gave a summary of all that has been done by geologists and scientists previous to this time, but it has no direct bearing on the Angat-Novaliches region. Becker's report, although written from limited observations, is an admirable paper on the geology of the Philippine Islands. His study of the rocks and his historical geology are interesting and in a general way affect the area under consideration. H. D. McCaskey [2] wrote a report on a geologic reconnaisance of the iron region of Angat, Bulacan. This region is just north of the Angat-Novaliches area. Adams [3] in his studies of the geology of southwestern Luzon touches lightly on the neighboring areas and briefly summarizes the geology. He produced a map showing the general trend of the limestone outcrops at Montalban, and shows both basalt and andesite east of Mariquina Valley. Dalburg and Pratt [4] also investigated the iron-ore region of Bulacan, and in their paper is given the best geologic data of the contigous region. They made a geologic map including Sibul and Norzagaray, and made an east-and-west cross section through Norzagaray. The portion of the present geologic map (Plate 2) north of Angat River is taken mainly from their map. H. B. Schenck [5] wrote a paper on the drainage control by jointing in Angat district, Bulacan Province.

The above are, more or less, general geologic reconnaisances, which, however, have served as fundamental bases for the unraveling of the local geology.

[1] U. S. Geol. Surv. 21st Ann. Rept. (1899–1900) pt. 3.
[2] Bull. Philip. Min. Bureau 3 (1903) pt. 2.
[3] Philip. Journ. Sci. § A 5 (1910) 57.
[4] Philip. Journ. Sci. § A 9 (1914) 201.
[5] Philip. Journ. Sci. 20 (1922) 57.

LOCATION AND EXTENT OF THE REGION

The region under discussion has an approximate area of 200 square kilometers and includes the region south of Angat River including Novaliches and a part of Mariquina Valley. Longitude of 121° east limits the area to the west and longitude 121° 10′ east limits it to the east. It lies in two provinces, and in-

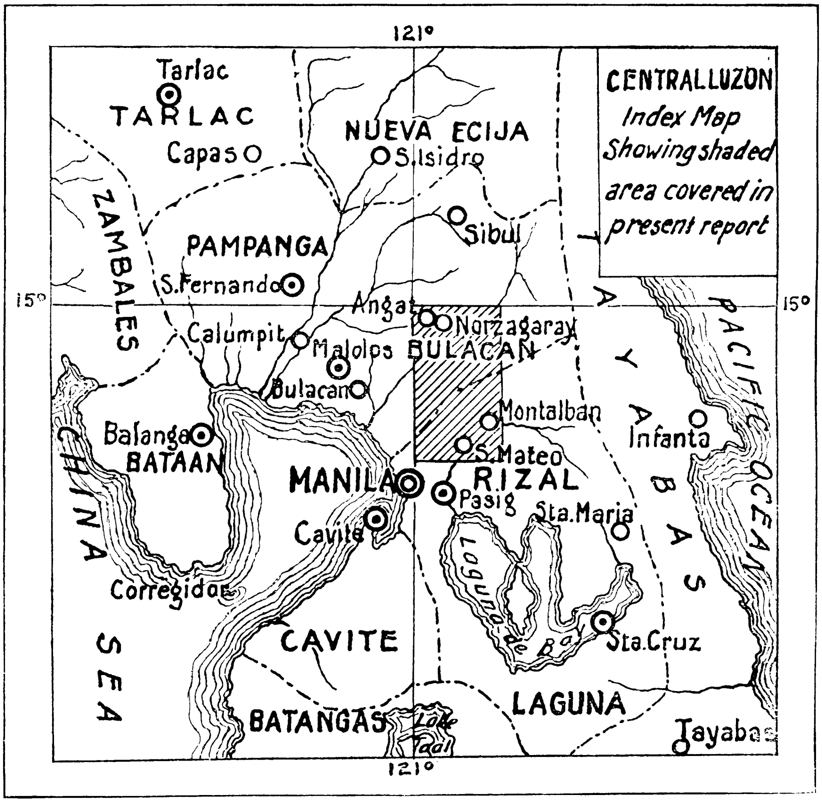

FIG. 1. Index map; the shading indicates the area covered by this report.

cludes the towns of Angat, Norzagaray, and San Jose del Monte, in Bulacan Province; and Montalban, San Mateo, and Novaliches in Rizal Province. (See index map, text fig. 1.)

CULTURE AND LIFE

The Angat-Novaliches region, while it is mountainous for the most part, is populated, though rather sparsely. The towns on the plains and in the low foothills are more thickly populated, and serve as supply stations and markets for those in the mountains.

Farming is the principal occupation on the plains. Sugar cane and rice are raised in the fertile Mariquina Valley. On account of the rolling topography in the foothills, rice paddies are absent, and varieties of rice which require no standing water are cultivated. A few big plantations have been noticed but as far as can be seen, very little is being done to develop them. All the desirable land in the neighboring mountains has been taken. Mountain rice, vegetables, bananas, and coconuts are grown wherever a suitable place can be found, and a few cattle are raised where grazing is good. The mountain people still make "caiñgins," or forest clearings, where they raise their staple foods, such as rice, camotes, and vegetables.

Lumbering is a popular occupation, especially among the people of Norzagaray, because Angat River with its swift current affords them a ready means of transporting their logs from the mountains to the town. Calantas, *Toona calantas* Merrill and Rolfe; ipil, *Intsia bijuga* (Colebrook) O. Kuntze; narra, *Pterocarpus blancoi* Merrill; and lanete, *Wrightia laniti* (Blanco) Merrill, are the principal forest products. Quarrying volcanic tuff for building stone is carried on in several places in Bulacan and Rizal. In San Jose del Monte a little placer mining is done, and cradles are used to recover the fine and coarse gold. Most of the inhabitants hunt and fish. In Angat River and its tributaries are some very palatable fishes.

Deer, wild hogs, and wild chickens inhabit the forests and the cogon-covered hills. "Alamid," or "musang" (*Viverra zibetha*) is common. Boas are said to be plentiful, especially in crags and rocky caverns. Small snakes abound, some of which, like the hooded cobra, are very poisonous.

Good roads connect all the towns to the provincial highways. From the towns, there are well-beaten trails leading into the mountains. Angat River, in spite of its dangerous rapids, is used as an avenue of transportation to Norzagaray.

In the higher mountains, there are some Negritos who seldom if ever go down to the towns. They are very peaceful and never bother anybody. Certain of the Tagalogs, called "remontados" and "taong gubat," or "mountain people," live independently in the inner recesses of the mountains. They are not as uncivilized as the Negritos, yet not as cultured as the other Tagalogs. They and the Negritos are mostly responsible for the caiñgins which are so harmful to the mountain vegetation. It is said that the taong gubat, or remontados, were refugees during the Philippine revolution, who made the mountain forests

their abode and have become so accustomed to them that they have made their permanent home there. They have intermingled with the Negritos to some extent, as may be seen from the Negrito traits easily discernible in some of the taong gubat.

However, the people usually met with in the mountains come from the towns and are of the civilized class. They work in the mountains and market their products in the towns.

The high mountains are thickly and heavily covered with forests. The dissected lava plateau is, for the greatest portion, covered with talahib, *Saccharum spontaneum* Linnæus, and small trees of which the alibangbang, *Bauhinia malabarica* Roxburg, is the commonest. Wherever there is limestone, there is almost always a rather thick growth of trees. Binayoyo, *Antidesma ghaesembilla* Gaertner; alibangbang, *Bauhinia malabarica* Roxburg; and duhat, *Eugenia cumini* (Linnæus) Druce, are the commonest trees; but others, as balete, *Ficus* sp., and mango, *Mangifera indica* Linnæus, can also be found. Boho, *Schizostachyum lumampao* (Blanco) Merrill, is plentiful everywhere, except in the high mountains. Very little "cauayan," *Bambusa spinosa* Roxburg, is found in the whole region.

PHYSIOGRAPHIC FEATURES

General.—The area under discussion forms a part of two great physiographic divisions of central Luzon. The southern and western low-lying tuffaceous portion is included in the Central Plain, and the eastern part, mostly mountains of extrusives and coarse intrusives, lies in the western flank of the Eastern Cordillera, which is composed of several high parallel ranges trending about north and south.

Relation of topography to lithology.—The region may be divided into five small areas which are underlaid by lithologically different formations and which have different mean altitudes above sea level. Though the geologic events of the past have been the fundamental factors in bringing about the difference in the mean altitudes of the five areas, the lithologic characteristics of the formations have also been influential, there being wide variations in their resistances to weathering and erosion. The division lines between these five areas, therefore, follow approximately the contact lines between the formations.

The low-lying plains.—Beginning from the southwest and west, the first topographic subdivision consists of the low-lying plains which are underlain by tuffs and tuffaceous sediments. The altitude above sea level varies between 35 and 85 meters. This is the eastern edge of the great Central Plain of Luzon.

The foothills.—The low-lying tuffaceous plains gradually merge into the foothills that form the second topographic subdivision. These foothills, ranging in elevation from 85 to 165 meters, are made up of tuffaceous sediments and alluvial material at the lower levels and conglomerates at the higher altitudes. They suggest a rolling topography of low rounded and flat hills with no special arrangement (Plate 6, fig. 1). Around Norzagaray, San Jose, and Novaliches, there may be noted elevated flats which are still preserved; two of them in particular are clear-cut and easily distinguished. One is at an approximate elevation of 85 meters, and the higher 135 meters more or less. After these two elevated flats had been noted, a general accordance of levels among the rounded hills was brought under observation and consideration. The highest flats are undissected remnants of plains of subaqueous deposition, uplifted from below shallow water, raised, and dissected, giving rise to the foothill topography. The higher hills and some of the lower hills of this subdivision are made up of fairly well-consolidated Pliocene conglomerates. At Lambak, from Angat River south to Santa Maria River where the upper Oligocene shales are present, the topographic expression is a depression because of the ease with which shales are eroded.

The dissected lava plateau.—The third subdivision is the dissected lava plateau underlaid by andesite and basalt, and some limestone. The elevation generally ranges from 165 to 350 meters, but east of Mariquina Valley it reaches about 430 meters. There is a marked accordance of levels among the flat or rounded summits as may be expected in a lava flow (Plate 5; Plate 8, fig. 1; and Plate 9, fig. 1). The average altitude of these flat summits or ridges is around 250 meters. West of Mount Lacotan there is a flat upland, with an area of about 4 square kilometers at an approximate altitude of 250 meters. This area has been slightly dissected and probably marks the approximate altitude of the top of the basalt flow, but as faulting and epeirogenic movements have occurred since its extrusion the present altitude is probably not the same as the original. Folding after the lava flow has resulted in higher peaks in some portions and lower in others.

There is no specific arrangement of the spurs and ridges in the lava area, because of the homogeneity of the rock and the fact that all of the rivers except the Angat have their sources here; consequently, the small tributaries have made an irregu-

lar dendritic pattern. In this area the drainage, with the exception of Angat River, is so young that jointing has not affected it noticeably. The result is a topography with a straggling pattern. The large limestone outcrops in the northwestern part of the region are included in this physiographic subdivision. These outcrops form prominent peaks and ridges, steep and craggy, towering above the surrounding country. In some places there are small isolated outcrops of limestone which generally protrude slightly above the lavas or have been exposed only by stream action.

The high ridges of limestone and the basalt mountains east of Mariquina Valley also belong here (Plate 5 and Plate 8, fig. 1). They are lithologically, structurally, historically, and genetically the same as those west of the valley, even though they have acquired a few of the characteristics of the topoghaphy of the high parallel ranges. The limestone outcrops tower above the surrounding country and have developed high peaks and steep slopes.

The Eastern Cordillera.—The fourth subdivision is the area of high parallel ranges made up of coarse-grained intrusive rocks (diorite, gabbro, peridotite, etc.) These coarse-grained rocks make up the next to the oldest formation known in the Philippines, the basal complex, which is the backbone of the Eastern Cordillera as well as of the big ranges of the Philippine Islands.

Mariquina Valley.—The fifth and last subdivision is the long, flat, straight valley occupied by Mariquina River, and known as Mariquina Valley. It is a graben, underlaid by recent alluvium, in fault contact with the low hills of tuff to the west, and the high basaltic mountains to the east. Structure, rather than lithology, has been the determining factor in the formation and development of this physiographic subdivision (Plate 2 and Plate 8, figs. 1 and 2).

RELATION OF TOPOGRAPHY TO STRUCTURE

The general monoclinal structure of the region may be detected from the general areal relations of the formations. The contact lines have a general north-south direction, except in the southern part where the contact lines swing around in a southeasterly direction following the low foothills and tuffaceous plains. The beds are younger to the west and older eastward into the mountains. They have a general monoclinal dip to the west, with minor undulations. This inclination is generally re-

flected in the abrupt eastern slopes of the ridges and more gradual western slopes. This relation, however, does not very well hold in the area which was covered by the lava flow.

Since a division into five physiographic portions has been made to show the relation between topography and lithology, these five portions will be taken up separately in discussing the influence of structure on the topography.

THE LOW-LYING PLAINS

The low-lying plains are of no interest in this discussion, since the tuffs and tuffaceous sediments are essentially horizontal and faults show no topographic expression, except, perhaps, in the general direction of the main rivers, or the abnormal course of a stream.

THE FOOTHILLS

The rounded foothills, underlaid by tuffaceous sediments and conglomerates which dip to the west, mark the beginning of the general monoclinal structure of the whole area. The conglomerates have a steeper dip than the younger sediments, sometimes reaching 13°. Because of this gentle western dip and the general westward slope of the whole area, there is a tendency for the western slopes of the hills to be flatter and gentler than the eastern slopes. In the foothills faulting has found some expression, but this is more obvious in the drainage pattern than in the peculiarities of the topography. Nevertheless, an unusual elongation of a hill has occasionally been observed along a fault trace. This area is separated from Mariquina Valley by a fault escarpment in tuff which abruptly terminates the rounded foothill topography (Plate 8, fig. 2). On account of the soft and easily eroded tuff, this escarpment is not well preserved.

In the Novaliches reservoir site, horizontal strata of water-laid tuff occupy the top of the flat hills, and there is a general accordance of levels at this altitude of about 135 meters above sea level. There is an absence of a general covering of alluvial material, except in the lower portions. These are uplifted terrains of pyroclastic material deposited and sorted under shallow water during the Pliocene when there were great volcanic explosions. These were uplifted in several stages, accompanied by slight folding and some conspicuous faulting. There are at least two stages of uplift recorded by two well-defined flat remnants, one about 85 meters and the other about 135 meters above sea level. Erosion has of course carved into these terrains the present topographic features.

THE DISSECTED LAVA PLATEAU

The dissected lava plateau with its undissected remnants is more fruitful in topographic expression of the local underlying structure. Here the andesite and basalt extrusions covered a region of limestone ridges which had already been folded, faulted, and eroded. After the lava flows, the region again suffered deformation. Due to the lava flood which covered this area, the dominant topographic feature is that of a dissected plateau with flat remnants and generally accordant summits, although erosion, folding, and faulting has somewhat couched its original structural simplicity.

In its upper course, Minoyan Creek follows a fault trace, sharply defined by a limestone escarpment which protrudes above the extrusives east of it and the sediments to the west as a long, narrow, prominent ridge covered with trees. Water gaps, underground rivers, and caves have been made in this limestone ridge by the creeks which cross it. Along Angat River, below Pared, there are high, steep, craggy peaks and ridges of limestone, bearing a luxuriant growth of trees, in marked contrast to the generally cogon-covered, rounded, or flattened hills of basalt and andesite. These prominent limestone outcrops were folded before the volcanic extrusions and acted as a barrier to the lava flows. The slopes of the limestone ridges are very steep; the eastern slopes oftentimes form cliffs due to the dip to the west and to vertical jointing. While the summits of the lava ridges and hills are flat or rounded, their sides are generally steep.

At Ke-Banban, there is a bowl-like depression of about 4 or 5 square kilometers. It is steeper on the northern side than on the southern side, and is hemmed in by ridges with only two narrow outlets, Ke-Banban Creek and Katitinga Creek. Since the structure can be deciphered only with difficulty in a lava-covered region, this depression, Ke-Banban Valley, has been tentatively ascribed to erosional processes, but because of its size and particularly its shape, it may have been greatly influenced by the underlying structure developed after the solidification of the lava.

East of Mariquina Valley, the basaltic mountains and the limestone ridges form part of the dissected lava plateau. In fact, this part of the plateau is nearer the source of the lava.

A prominent feature in this area is the steep, craggy, jagged ridges and high peaks of the elongated outcrop of Montalban limestone or Binangonan limestone, which stand out in sharp

contrast to the undulating skyline of the mountains of intrusives and extrusives (Plate 5). This limestone, especially at the Montalban dam where there is a gap, is badly fractured and fissured and perhaps has an almost vertical altitude, producing such prominent features (Plate 1 and 28). Extensive caves are present in the limestone at the dam, high above the present stream level. This limestone outcrop is elongated in a north-south direction in accordance with the general structure of the area.

The prominent peaks of this subdivision are Mount Salacot, 319 meters; Mount Bulak, 305 meters; Mount Osboy, 213 meters; Mount Pakiling, 220 meters; and Mount Tacbohan, 227 meters; the limestone peak on the southern bank of the Angat River at Pared, 305 meters; Mount Haponang Baboy, 480 meters; and Monut Pamitinan, 414 meters.

The Eastern Cordillera.—Ickis [6] crossed the Eastern Cordillera from Infanta, Tayabas, to Tanay, Rizal, and developed a cross section of the country he traversed. His reconnaisance was superficial and failed to show the relation of rocks of the basal complex to the overlying rocks. Adams [7] in his reconnaisance of southwestern Luzon, included a map, which, although incomplete as far as the Eastern Cordillera is concerned, gives an idea of its structure. It would seem, from the reports of the above geologists, that the Eastern Cordillera is a closely folded anticlinorium. The Angat-Novaliches region is on the western flank of this anticlinorium, and in this report is referred to as a monocline.

The axes of this anticlinorium and its auxiliary folds have a north-south direction and are parallel to the eastern coast line of Luzon. This is also the direction of the long axes of the intrusions and of the traces of the long principal faults. It is conceded that the main tectonic lines of Luzon in this vicinity lie in the same direction. The principal ranges of the Eastern Cordillera follow this general alignment, and it can be seen that the structure of this physiographic province has determined the carving of its present topographic features and characteristics.

The ranges of the Eastern Cordillera are fairly well aligned, and have steep slopes, probably due to the severe folding that the region has suffered and to the resistance of the rocks to weathering. Although there is no accordance of levels in the summits of the ridges, the skyline is not rough and jagged.

[6] Philip. Journ. Sci. § A 4 (1909) 483.
[7] Philip. Journ. Sci. § A 5 (1910) 57.

There are few towering prominences; a few peaks, according to Adams,[8] reach an altitude of about 1,400 meters (about 4,550 feet). In the area under discussion, the most prominent peaks are Mount Balabag, 798 meters high, and Mount Katitinga and Mount Lacotan, both 427 meters high. The bases of these peaks are elongated in a north-south direction following the general trend of the structure.

West of Mount Lacotan and Mount Katitinga, starting from the northwest corner of Mariquina Valley north to Ipo River, there is a long, marked, narrow depression, or trench, which is partly occupied by Pagup River (Plate 9, fig. 2). This trench is very conspicuous and can be followed easily. It is the northern continuation of fault 7 (Plate 2) on the western side of Mariquina Valley, and here marks the eastern limit of the dissected lava plateau.

MARIQUINA VALLEY

There is a strongly pronounced fault scarp in the western flank of the basaltic range on the eastern side of Mariquina Valley. This escarpment is very straight and well preserved and exhibits triangular facets at the end of its spurs, and here and there, faulted-off valleys (Plate 7, figs. 1 and 2; Plate 8, fig. 1).

Since there are fault scarps on both sides of Mariquina Valley, it is logical to assume that Mariquina Valley is a block which was faulted down, a graben. Its shape and direction and the relation to the structure and its unmistakable topographic features support this theory.

DRAINAGE

Drainage patterns frequently give one an idea of the structure of a region, but sometimes a region has to be studied well before the relation between drainage and structure can be understood. This is true of the Angat-Novaliches region.

The principal drainage system is Angat River with its tributaries. It has its source well up near the summits of the high ranges of the Eastern Cordillera and flows in a broken line, or zigzag, deeply incised in steep valleys and cañons in a general southerly direction, following the north-south alignment of topographic features and structure, until it strikes fault 2 (Plate 2) near the mouth of Ipo River. Then it assumes a general northwesterly course, not winding around, but, as in its upper

[8] Op. cit. 81.

course, zigzagging with sharp turns. It here follows the general direction of fault 2, which is probably the influencing element for its present lower course. The upper course of Angat River probably is controlled by a major fault, which may be a continuation of fault 7 (Plate 2), on the western side of Mariquina Valley. The abrupt turn of Ipo River, just north of Mount Katitinga and its course from there on, may also have been influenced by the same fault or by an auxiliary fault. The broken line, or zigzag character, of Angat River is an expression of the jointed structure of the rocks and also is probably due to small auxiliary faulting.

Angat River (Plate 9, fig. 1) is a very active stream, carrying a large volume of water at a fast rate, flowing over waterfalls in its upper courses and over rapids in its lower courses. It has cut a deep gorge, especially at Pared (Plate 6, fig. 2) where the stream is narrow and the banks high and almost perpendicular. It has only a few short tributaries from the west, but many more and longer tributaries from the east. Instead of being drained by shorter tributaries to the upper Angat River, the northernmost portion of the area is drained by long tributaries, such as Sapang Balete, Bayabas River, and Maasim River, which flow westward until they eventually find their way into the lower course of Angat River. From Ipo River to Norzagaray, its tributaries are merely small ravines. The positions of these tributaries further support the fact that the western slopes are much gentler than the abrupt eastern slopes, and since this is a reflection of the regional monoclinal structure, the relation between the drainage pattern and the structure is evident.

Santa Maria River and Sapang Alat are the two rivers south of Angat River which have general westerly directions. Santa Maria River seems to follow the direction of fault 3 (Plate 2), just as Angat River follows fault 2. Minoyan Creek, Osboy Creek, Biniakdan Creek, Katitinga Creek, and Ke-Banban Creek are all tributaries of Santa Maria River. These tributaries have their sources in the dissected lava plateau and drain most of it. The streams and creeks have general westerly directions, although the pattern has no particular arrangement. Sapang Alat with its tributaries drains the southern part of the lava area. Santa Maria River and Sapang Alat do not flow into Angat River, but empty into Bulacan River, one of the distributaries in the great Pampanga River delta.

Minoyan Creek, a tributary of Santa Maria River, follows fault 1 (Plate 2) a short distance, along a limestone escarpment.

The southern portion of the whole area is drained by Novaliches River, which flows southward and southwestward. This river and some of its tributaries show the influence of faulting, as may readily be seen from the accompanying map (text fig. 2).

FIG. 2. Faulting at Novaliches River.

The first remarkable feature is the angularity of the pattern; Camates Creek and Novaliches River are almost parallel in this vicinity. Then Novaliches River makes a right angle turn and meets Camates Creek. Since the formation here is tuff and tuffaceous sediments with only a small inclination, it cannot be that rock structure has had any influence in the development of this pattern. This system of faulting will be discussed more fully under structure.

The Mariquina River system has many tributaries in its mountainous watershed and their sources are well up in the ranges of the Eastern Cordillera. While the general trend of the system is westward, cutting through the ranges, most of the tributaries are parallel or subparallel to the structural lines of the Eastern Cordillera. It has cut a remarkable gap in the limestone at the Montalban dam. This river, or its predecessors, is probably responsible for the caves in the limestones at the dam. Stream pebbles are common in the caves. Mariquina River, after it passes the mountains, reaches the flat Mariquina Valley, strikes fault 7, and makes a sharp turn to the south where the stream meanders on an alluvial plain in the graben. Fault 7 with its low escarpment of tuff has limited its meanderings and side cutting to the west. In the valley there are several long tributaries from the east, but few and short ones from the west. The area just west of Mariquina Valley is drained mostly by the Novaliches River system and the San Juan River system.

Wawa Creek is a north-flowing branch of Mariquina River joining it near the office of the Montalban reservoir. It has followed a very sharp anticline in the shales of the Batan formation. It is also probable that a fault marks the western side of this valley. This valley is remarkable in that a low limestone ridge running through the center looks as if it had slidden down from the western slope.

GEOLOGICAL FORMATIONS

GENERALIZED SECTION

Cenozoic.
- Quaternary.
  - Recent alluvium; 0 to 20 meters; maximum altitude 65 meters.
  - Pleistocene alluvium; 0 to 35 meters at elevations between 65 and 150 meters.
- Tertiary.
  - Pliocene.
    - Guadalupe tuff; 150 meters at least, in the area.
    - Alat conglomerates; 35 meters ±.

Miocene.
- Mariveles andesite; 65 meters maximum.
- Antipolo basalt.
  - Basalt; 350 meters maximum.
  - Basalt; "Volglomerate"[9] 20 meters ±.

Oligocene.
- Lambak shales and sandstones; 100 meters ±.
- (Vigo formation.)
- Binangonan limestone; 20 to 200 meters ±.
- Batan formation; 100 to 500 meters ±.
- (Coal Measures.)

Eocene.
- None observed, probably absent.

Pre-Tertiary.
- Mesozoic.
  - Post Jurassic or Cretaceous.
    - Pyroxenites, peridotites, serpentines.
  - Jurassic?
    - Radiolarian cherts?
  - Triassic?
- Paleozoic.
  - Permian.
    - Basement complex: Diorites, gabbros, etc.
  - Pre-Permian.
    - Granite and granodiorite.

PRE-TERTIARY

THE PRE-PERMIAN ROCKS

In the area included in this paper, the outcrops of granite and granodiorite are very small, and the conclusions were drawn from the extensive outcrop of granite just north of the present area. This granite is believed to be the oldest rock in the region, even older than the "basement complex" which forms the backbone of the Cordilleras.

Granite.—At Sapang Caliñgao, two specimens of granite were collected by Pratt and Dalburg, one of them at the diorite contact.

The specimen collected far from the contact is a light-colored, medium to coarse-grained rock. Its texture under the microscope is hypautomorphic coarse inequigranular, the feldspar sometimes being automorphic. The essential minerals are quartz, orthoclase, and some plagioclase with hornblende, hem-

[9] "Volglomerate" is a term proposed for a lava flow which has included in it much alluvial material of heterogeneous composition. Agglomerate is a chaotic assemblage of coarse angular pyroclastic materials of a more or less homogeneous composition.

atite, zircon, and apatite as accessory minerals. Most of the hornblende has altered to pistacite (epidote), chlorite, and iron oxide. The feldspars are greatly weathered and are altered to kaolin, pistacite, and chlorite. The granite is very greatly altered.

The specimen at the diorite contact is a light greenish-gray, dense, crystalline rock, jointed and cleaved. Under the microscope its texture is fine, granular, sutured, with occasional xenomorphic orthoclase phenocrysts. The essential minerals are quartz and orthoclase with magnetite, apetite, and zircon as accessories. The secondary minerals are pistacite, zoisite, chlorite, iron oxide, kaolin, and opacite. Grossular garnet occurs to the intrusion of diorite. The specimen is full of fissures lined with secondary quartz and limonite. Dalburg and Pratt, who collected this specimen, observed its occurrence at the contact with diorite. It is, therefore, a metamorphosed facies of the old granitic stock. Weathering is far advanced, and the original ferro-magnesian minerals have all been altered to chlorite, pistacite, and iron oxide. The feldspar is also weathered to kaolin, chlorite, and pistacite. The diorite was probably intruded along the border of the granite stock, because the texture of this specimen and its composition seem to point to a border or contact facies.

At Santol, Smith collected a specimen of granite and marked it, "Diorite, near granite contact." Megascopically it is fine greenish-gray granular rock with pyrite disseminations. Under the microscope the texture is inequigranular microcrystalline, hypautomorphic porphyritic, intruded by a hyaline microlitic omniversal to trachytic rock probably an andesitic equivalent of the old diorites. The mineral composition of this granite is much the same as the other specimens. It is clear, from its contact relation, that it had been intruded by the same magma which gave rise to the diorite.

The granite is greatly altered and weathered. Sometimes the ferromagnesian minerals have been altered and the feldspar is almost beyond recognition. The basic rocks, while they are somewhat altered and weathered, are still comparatively fresh.

The evidence points to an older age of the granite intrusion, and it is probably the oldest rock known in the Philippine Islands. It indicates, therefore, that the oldest rocks were acidic. However, not all granites of the Philippines are of this age. There are younger granites in other localities, as the Paracale district, where granite was intruded into Tertiary sediments.

Rhyolite.—Schenck collected a specimen of an acid extrusive at Pared, Angat River. Megascopically it is a weathered, greenish dark-gray, fine, crystalline, calcareous rock with pyrite grains. Under the microscope its texture is sutured, microcrystalline hyalopilitic, and somewhat microlitic. The essential minerals are orthoclase and quartz; with hornblede, apatite, zircon, topaz, magnetitte, pyrite, and chloritic glass as accessories. The secondary minerals are pistacite, chlorite, calcite, iron oxide, and kaolin. Due to the accessory and secondary minerals the rock is dark. It is probable that the rock is an altered rhyolitic lava. Rhyolite has also been noticed in alluvium in Bocaue, brought down by Santa Maria River. This rock is probably an extrusive phase of the old granites, which outcrop farther north.

Granodiorite.—A specimen of granodiorite was collected by Schenck in Sapang Paila, a branch of Angat River near Paila. It is light colored and coarse granular, with magnetite and pyrite disseminations. Megascopically, it looks like granite. Under the microscope the texture is hypautomorphic granular with intersertal subrounded quartz grains. The essential minerals are andesine, quartz, and just enough orthoclase to make it a granodiorite. Magnetite, hornblende, pyrite, zircon, and apatite occur as accessory minerals with kaolin, chlorite, and limonite as secondary minerals. This rock may belong to the same age as the granite, since it is more acid than the rocks of the basement complex.

THE BASEMENT COMPLEX OF PROBABLE PERMIAN AGE

In spite of the greater age of the granite, the present writer, besides conforming to an established term, persists in assigning the term "Basement Complex" to the basic igneous rocks, which largely make up the cores of the Philippine cordilleras, because the granite outcrops are probably only small local lacolithic or stock intrusions.

THE PLUTONIC IGNEOUS ROCKS OF THE BASEMENT COMPLEX

Hornblende gabbro.—This specimen is a piece from a bowlder float at the mouth of Ipo River. There are many of these bowlders and on account of their sizes which reach several feet in diameter, it is clear that their source could not have been far, although Angat River and its branches are powerful during the rainy season. The rock is dark, coarse-granular with large feldspar and hornblende crystals. In some bowlders there is a sharp conspicuous band in which the minerals are much larger.

This band is not intrusive into the mass. Under the microscope the rock is very coarse-granular hypautomorphic, and in places ophitic. It should be stated that ophitic hornblende gabbro is common. The feldspar is labradorite. Hornblende is the dark mineral; magnetite also occurs. The secondary minerals are chlorite, kaolin, and talc.

Diorite.—Diorite is another common rock in the mountain cores. Since it is the rock most commonly in contact with the older and younger rocks of the basement complex, it was probably intruded before the gabbro, which seems to occupy the central part of the mountain cores. Samples of diorite were collected along Ipo River near the contact with the Miocene lavas. There is also diorite float in Angat River and Ipo River. Megascopically, this diorite is a fine-granular, dark rock with occasional small plagioclase phenocrysts. Under the microscope the texture is allotriomorphic granular to ophitic. Hornblende predominates over the plageoclase, which in this case is oligoclase-andesine. Magnetite disseminations are frequent. Fine-grained diorite is very common. At Marapo River, Matulid, Angat, Pratt and Dalburg collected a very fine-grained diorite of almost the same composition as the above. The hornblende is seen altering to epidote, chlorite, and iron oxide. It has been observed that pistacite, or epidote, is a common alteration mineral in the igneous rocks of Bulacan.

Dacite.—This specimen was collected by Schenck at Paila, Angat River. It is a fine-grained, greenish-gray rock with parallel elongated cavities which are probably due to an application of pressure after the rock full of rounded gas pores had solidified. These cavities have been filled with the yellowish-green pistacite. Under the microscope the texture is automorphic porphyritic microcrystalline, or microlitic subparallel to diverse. In places there is a subparallelism of the microlites to the elongated cavities. The entire rock is somewhat hyaline. The minerals are phenocrysts and tiny laths of plagioclase, irregular grains of quartz, magnetite, apatite, pistacite, chlorite, iron oxide, and kaolin.

Dacite porphyry has also been found north of the present area, at Talagio River and Maon Creek, by Dalburg and Pratt. in the Camachin iron-ore deposits syenodiorite has also been collected.

BASEMENT COMPLEX DIKE ROCKS

At Pared, near Paila, on Angat River, there is a small locality of basement complex rocks with acidic and semiacidic dike

rocks (Plate 11, fig. 1, and Plate 14, fig. 1). A dacitic dike rock at Pared is dark gray and dense, with epidote in the cavities. Under the microscope the texture is fine-granular, hyaline-crystalline, with felty to subaparrallel laths of andesine and some granular quartz. The cavities are filled with epidote and secondary mosaic quartz. There are many quadratic sections of magnetite. Zoisite, glass, chlorite, kaolin, and iron oxide are present. The magnetite and the chlorite make the rock appear dark. Another dacitic dike rock is bluish gray and dense. Under the microscope it is cryptocrystalline granular with a microlite groundmass. In places it is automorphic porphyritic. There is also a subparallel arrangement of microlites and feldspar laths. The phenocrysts are andesine. Granular quartz and orthoclase occur with laths and microlites of andesine. Hornblende magnetite, chlorite, kaolin, and iron oxide also occur. This dike was found close to quartzitic dike rock.

The quartzitic dike rock is composed of a white dense rock. Under the microscope it is fine cryptocrystalline almost equigranular; mostly quartz, a little orthoclase, zircon, kaolin, limonite, and epidote. These dikes are probably the last to be intruded. Since there are many dacitic dike rocks, it is probable that dacite was one of the last products of the intrusion of the rocks of the basement complex. These dike rocks are in anorthosite and other old fine-grained extrusives.

EXTRUSIVES OF THE BASEMENT COMPLEX

Anorthosite extrusive.—This specimen (Plate 20, fig. 1) was collected at Batong Anay, Angat River, under the Binangonan Oligocene limestone. It is a dense black rock with submetallic luster. Under the microscope its texture is irregular, haphazard, finely crystalline to hypautomorphic porphyritic with a groundmass of xenomorphic orthoclase and hypautomorphic elongated laths of plagioclase. The minerals are labradorite phenocrysts, granular orthoclase, magnetite in great amounts giving a dark color and a metallic luster to the rock, glass, iron oxide, sericite, and kaolin. No ferromagnesian minerals were observed, and neither were there any secondary minerals derived from them. The Miocene lavas with which it may be confused have a different texture and composition and contain much hornblende. This rock is a Pre-Tertiary anorthosite, and this opinion is based on its position under the Oligocene limestone. The limestone at the contact is not metamorphosed; therefore, this anorthosite cannot be Post-Oligocene.

THE BARUYEN CHERTS

Cherts of probable Jurassic age.—The outcrop of these cherts (Plate 20, fig. 2; Plate 21, fig. 1) are rare, small, and isolated. They have been reported from this region by former geologists. At Ipo River, about 5 kilometers from its mouth, there is an outcrop about 35 meters long and about 15 meters high. The chert is very hard and dense, and emits a ringing metallic sound when struck with a hammer. It is evenly stratified; the beds are about 2.5 centimeters thick. The beds are reddish brown or bottlegreen, and one color or the other generally persists in each bed. The strata are tilted and strike north 13° east and dip 60° west.

Under the microscope it is seen that the red chert, or jasper, is coarser and contains hematite which gives it the brownish-red color. Included in it are many angular grains of feldspar, mostly plagioclase, and some quartz, and their clastic nature can be easily distinguished. These clastic grains are embedded in the hematitic and opacitic semicrystalline or chalcedonic silica.

The green chert owes its color either to chlorite or to glauconite; it is fine microcrystalline chalcedonic silica, and clastic grains are very rare. No radiolarians were noticed in the green cherts, but radiolarian tests were observed in the red chert (Plate 20, fig. 2). Smith has published pictures of radiolarians from the red cherts of Ilocos Norte, called the Baruyen formation,[10] which probably belong to the same age and formation as the Bulacan cherts. These cherts may also be correlated with the cherts of the Danau formation of Molengraaff [11] in Borneo. Martin[12] found similar cherts in a more or less similar stratigraphic position in the Moluccas.

The age of the Baruyen cherts is probably Jurassic.[13] Molengraaff also gives this age to the cherts of Borneo. Since the fragments of feldspar are mostly plagioclase, it is probable that these cherts were laid down after the intrusion of the basic igneous rocks of the basement complex. Furthermore, these cherts are generally found on the flanks of the high cordilleras. The cherts have not been intruded by the basic igneous rocks, and

[10] Geology and Mineral Resources of the Philippine Islands, Manila, Bu. Sci. Publ. 19 (1925) 11–74.

[11] Geological Exploration in Central Borneo. Leyden (1902) 414–415.

[12] Reisen in den Molukken, Geol. Teil. Leyden (1902) 164.

[13] Smith, op. cit. 71.

are generally found in areas which have been covered by the Miocene lavas or by the Oligocene limestone.

According to Molengraaff these radiolarian cherts are probably deep-sea deposits on account of the fineness of the sediments, their uniformity, and the presence of radiolarian tests.

CRETACEOUS ULTRA-BASIC INTRUSION

Augitite.—A sample of augitite (Plate 21, fig. 2) collected on Ipo River (see map, locality 5) is megascopically a dark-green, granular rock with dark phenocrysts. Under the microscope it is hypautomorphic porphyritic with a hypocrystalline to vitrophyric opacitic groundmass. Its minerals are mainly augitite, some plagioclase, a little hornblende, glass, and chlorite. This is an extrusive or hypabyssal rock, probably a differentiation facies of the intrusion of pyroxenites, peridotites, and serpentines, which came after the cherts were deposited and which are found throughout the Archipelago. Pratt and Dalburg also collected a sample of augitite in the Camaching iron-ore deposits with some secondary quartz. These rocks have been observed intrusive into Baruyen cherts in other localities, and probably are Cretaceous.

TERTIARY

OLIGOCENE

Batan formation (*Coal Measures*).[14]—On account of the lava flows, there are few and very poor exposures of the lower Oligocene sediments, called the Batan formation beneath the Binangonan limestone which is also Oligocene. Heretofore, writers have given the Binangonan limestone and the sediments below it a Miocene age, but it is here assigned to the Oligocene on the strength of geophysical evidence. Moreover, recent faunal and stratigraphic studies tend to determine the Oligocene age of these formations.

At Baraka, on Angat River, black shales were encountered under the Binangonan limestone and under these a conglomerate (Plate 13, fig. 2). At Bicti, probably beneath the limestone, a small outcrop of fine, well-rounded conglomerate was noticed, somewhat sandy and disintegrating. These are the only exposures of the basal Oligocene conglomerate brought under observation, and they are far from satisfactory. Pratt and Dalburg [15]

[14] Dalburg and Pratt, Philip. Journ. Sci. § A **9** (1914) 213, call this Miocene.

[15] Philip. Journ. Sci. § A **9** (1914) 213.

found along Bayabas River, a little distance to the north of the present area, under the Binangonan limestone, shale, tuffaceous sandstone, quartz sandstone, and conglomerate. Pratt and Dalburg assign them to basal Miocene, since the conglomerate is found immediately above the granite and older effusives. In Santol Creek they found the same relations, and also noted a white crystalline marble close to the bottom of the series. The thin, white, crystalline limestone at Bakas may be the corresponding limestone in the present area, since it appears as to be below the black shales nearby. It contains the same Foraminifera or *Lepidocyclina* as the Binangonan limestone (Plate 26, fig. 2). These sediments, consisting of conglomerate, limestone, and shales, are probably not thick along Angat River.

At Montalban Gorge, on the northern bank, there is an outcrop about 200 meters long of the Batan formation, striking north 24° east and dipping from 60° to 70° east (Plate 18, fig. 1). The exposed strata are at least 150 meters thick. Farther downstream the outcrops are covered, but the limestone on top shows clearly that this is the crest of a sharp anticline. There are thick exposures of these shales and sandstones along Wawa Creek which flows from the south joining the main river a little distance downstream. Here the thickness of the Batan shales may exceed 500 meters.

The sediments are for the greater part dark hardened shales with beds of fine dark sandstone, and here and there a thin limestone layer. No coal was found at Mariquina River, but along Puray River, in the northern extention of these outcrops, and in the upper Wawa Creek, coal has been observed. It may be said, in passing, that most of the coal in the Philippines is found in this formation.

Binangonan limestone.[16]—The Binangonan limestone, of middle Oligocene age, is a gray to white crystalline fossiliferous limestone which has been metamorphosed both by dynamic movements and by the Miocene extrusives. It is badly broken up and jointed, its attitude being determinable only in a few places. In general, the strike is between north 13° east and north 30° east and usually dips west from 13° to nearly vertical except where it is folded into an anticline. Solution cavities and caves abound in this limestone, among which are the caves at Montalban Gorge (Plate 17; Plate 18, fig. 2), Suclib Cave (Plate 12, fig.

[16] Geology and Mineral Resources of the Philippine Islands, Bu. Sci. Publ. 19 (1925) 310; and G. I. Adams, Philip. Journ. Sci. § A 5 (1910) 79–84.

1) on Angat River, and the caves at Bicti. An underground river flows into Angat River at Kay Basa rapids (Plate 12, fig. 2).

There are some extensive outcrops of this limestone. It is very conspicuous below Pared on Angat River, along Minoyan Creek down to Santa Maria River (Plate 10), and in the Montalban Gorge district where it makes high peaks and ridges. There are also many small isolated outcrops throughout the area which fall in two lines trending north 13° east. The significance of this will be discussed under Structure. Suffice it to say that the Binangonan limestone and older formations were covered by the Miocene lava flows except in their higher portions where previous folding and faulting had pushed them up causing their outcrops to be irregular in distribution.

Naturally, the lava flows metamorphosed the limestone, but the absence of contact metamorphic minerals is surprising. At Katitinga Creek about 1 kilometer north of Ke-Banban, the limestone is in contact with both basalt and andesite, it is dark gray and is full of dark specks, mostly magnetite. Under the microscope it is seen that the andesite and the limestone have mixed together so that at the contact the rock is calcareous but it has a decided andesitic texture (Plate 24, fig. 2; Plate 25, figs. 1 and 2). A little farther from the contact, the limestone includes many grains of feldspar, some hornblende, and magnetite. No typical contact minerals were found. It is clear that the hot andesite fused and absorbed much limestone when the lavas were extruded producing the mixture just described. A little distance away from the contact there was much less fusion.

The fossils found in this limestone are mostly corals and lepidocyclinas which Faustino has ascribed to the Oligocene age. The physical history of the region strongly supports the Oligocene age of the Binangonan limestone and its associated formations. On account of close folding and faulting, and the fact that the lava flow has concealed much of its structure, its thickness could not be accurately measured. In places it may be only about 20 meters thick; while in others, as at Montalban, it is probably 200 meters or more.

Lambak shales and sandstones (probably equivalent to the Vigo formation).[17]—West of the outcrop of Binangonan limestone at Minoyan Creek there is a long comparatively narrow depression occupied by shales and sandstones, which are some-

[17] W. D. Smith, op. cit. 78 and 80; and G. I. Adams, op cit. 79–84.

what tuffaceous in places. This series of sediments is conformable on the Binangonan limestone and is about 100 meters thick. Since the above depression is called Lambak, this series has been designated as the Lambak shales and sandstones, and is of upper Oligocene age. It consists mostly of moderately hard, somewhat cherty, greenish-blue shales, greatly laminated, jointed, and folded. There is a tendency towards concentric lamination suggesting concretionary structure. There are a few layers of medium-coarse, light-colored sandstone which is somewhat tuffaceous.

This formation is undoubtedly wide-spread over the area, but erosion has worn it from the ridges, and the former depressions where they were undoubtedly present, have been covered by the lava flows. In Lambak it was not reached by the lava flows, on account of the protection afforded by the limestone escarpment along Minoyan Creek.

This formation has been described from the area farther north by Dalburg and Pratt,[18] but it is probably much thicker there. They assigned it to the Upper Miocene, but in the present paper it has been assigned to the Oligocene, being conformable on the Binangonan limestone.

MIOCENE

The Miocene lava flows.—The Miocene in this area is represented wholly by lava flows which probably emanated from the region around Antipolo, Rizal. On an eroded topography of greatly disturbed Oligocene and older rocks, basaltic lava flows probably overran the region, during the middle Miocene.

Volglomerate.—The oldest flow or the lower part of the basaltic flow is conspicuous for the great amount of included alluvial material of heterogeneous composition, produced by the Lower Miocene erosion. Because of its heterogeneity this is not truly a volcanic agglomerate and the term, "volglomerate" has been proposed for it. Most of the included pebbles are clearly alluvial, because well-rounded pebbles are common. Good outcrops of this volglomerate (Plate 11, fig. 2) may be seen along Ipo River and Angat River. These pebbles are mostly diorites, gabbros, and old extrusives. The matrix of the basaltic volglomerate is somewhat mottled in appearance. Under the microscope it has a glassy fluidal texture, enveloping, as it were, crystalline particles (Plate 23, fig. 2). The glass is yellowish green to green, due to iron oxide and chorite.

[18] Philip. Journ. Sci. § A 9 (1914) 212.

Elongate cavities are common. The volglomerate itself is thin, probably not exceeding 20 meters.

The Antipolo basalt.—Immediately above the volglomerate is the basalt proper (Plate 22, fig. 1). It is a dark, fine, crystalline rock, sometimes very dense. Under the microscope it is automorphic porphyritic with a groundmass of glass, or microlites, or both. Phenocrysts are labradorite and sometimes small crystals of hornblende. It contains characteristic magnetite in flaky disseminations. Chlorite, hematite, kaolin, limonite, and opacite are found as secondary minerals. The basalt varies in texture in different localities, but the component minerals are the same. It is about 200 meters thick, and covers most of the area under consideration but does not extend west of Minoyan Creek. The map (Plate 2) shows the areal relations.

Basalt obsidian or variolite (Plate 22, fig. 2; Plate 23, fig. 1).—At Ipo River, about 4 kilometers from its mouth, a dark-greenish rock with white phenocrysts and a suggestion of flow structure or semischistosity, which may be due to flow or to pressure, was encountered. Under the microscope it is porphyritic automorphic, with a groundmass that is hyalinocrystalline felty to parallel laths, with spherulites, axiolites, and lithophysæ made up of delessite (chlorite). The axiolites are parallel to each other. The minerals are orthoclase, labradorite, quartz magnetite, delessite, chlorite, kaolin, calcite, iron oxide, and topaz. Some places show evidence of a later injection of the same magma into the then hardly solidified magma. This is a basic, glassy, extrusive rock with some orthoclase phenocrysts and smaller crystals of labradorite. It may be termed basalt obsidian or variolite. This rock has some similarity in texture and composition to the matrix of the volglomerate.

Tachylite (Plate 23, fig. 2).—A sample of float from the mouth of Ipo River is a porphyritic or an agglomeratic basalt glass, probably a tachylite. It is a dark-mottled dense agglomeratic rock. Under the microscope the texture is hyalinocrystalline automorphic porphyritic. The groundmass is dark and glassy with microlites and automorphic tabular crystals. The minerals are labrodorite phenocrysts and microlites, glass, magnetite, secondary quartz, hematite, chlorite, calcite, kaolin, and talc. Some cavities are concentrically filled with calcite, chlorite, and cryptocrystalline quartz.

The Mariveles andesite (Plate 24, fig. 1).—This andesite is referred to as the Mariveles andesite since it is the formational name in the Philippines for the Upper Miocene andesite flows.

This andesite lies on top of the basalt flows. Its appearance and texture varies in different localities. Near Minoyan Creek at Butarero it is very badly weathered. At Katitinga Creek near Ke-Banban it is coarse porphyritic with hornblende phenocrysts, and one mile west of there it is much coarser and darker. At Mount Capitan Pascual it is medium coarse and the dark phenocrysts are small. Under the microscope, the texture is automorphic to hypautomorphic porphyritic with a glassy to cryptocrystalline dark groundmass. The feldspar is oligoclase to oligoclase-andesine. Hornblende is very common; hypersthene and augite, rare. Some biotite may have been derived from the hornblende. Magnitite is very conspicuous, as in the basalt. The andesite occupies the western edge of the Miocene lava area. It is about 65 meters thick, but it was probably more extensive than it is now, as denudation must have worn off a great portion of it. No indication as to its source has been found in the area. It also seems that the andesite flow did not cover the higher elevations of basalt and only flanked it on the lower altitudes to the west. Andesite elevations do not exceed 200 meters above sea level, a fact which indicates that the fissure or vent for the andesite was lower than the source of the basalt. Adams [19] reported andesite associated with the basalt east of Mariquina Valley. Ickis [20] in his cross section from Infanta to Tanay also encountered andesites. Whether these andesites belong to the same flow, or are merely contemporaneous, is not known.

PLIOCENE

In a shallow sea that occupied the central plains the Pliocene sediments and volcanic ejectamenta were deposited on a sinking bottom. There are two members; namely, the Alat conglomerate and the Guadalupe formation which is mostly tuff.

The Alat conglomerate (*Plate 14, fig. 2*).—This formation is at the base of the Pliocene and marks the unconformity on the Miocene lavas. The type section is in Sapang Alat where it strikes about due north and dips as much as 13° downstream to the west; in places it is gently folded. It is a marine littoral conglomerate and its eastern extent marks more or less the boundary of the Pliocene sea at its greatest extent. The conglomerate itself is well cemented and the pebbles reach 45.72 centimeters in diameter, but the average size is about 1.3 centi-

[19] Philip. Journ. Sci. § A 5 (1910) 77.
[20] Philip. Journ. Sci. § A 4 (1909) 483–489.

meters. The material is well sorted, and the stratification is well defined. There are local unconformities and cross beddings. A few thin layers of sandstone, sometimes tuffaceous, and some greenish olive drab shales are interbedded with the conglomerate beds, which are about 35 meters thick. The pebbles are composed of all kinds of rocks—diorite, gabbro, basalt, andesite, limestone, etc. Many of the limestone pebbles have been partially or entirely dissolved out of the matrix which is gray, calcareous, coarse, semiangular to subrounded, inequigranular, and with tiny pebbles.

The Guadalupe tuff formation.—The Guadalupe tuff formation is a thick series of well-stratified andesitic tuff and tuffaceous sandstones, shales, and conglomerate, found in the western and southern portion of the area at the edge of the Central Plain. The beds are generally between 30 centimeters and 1.5 meters thick. In this area, the total thickness is probably only about 150 meters, but to the west and south, the beds are thicker. Artesian-well records show that they are very thick. The strata are generally horizontal, but near the foothills they dip to the west, partly due to the original deposition on a slope. Gentle folding in the Alat conglomerates shows that slight compressive movements have taken place after the Pliocene. Near Norzagaray the tuff is gently folded. Fossil wood and fossil leaves have been found in the Novaliches reservoir dam site. Locally it is very conglomeratic on account of former streams which deposited coarse material in times of torrential downpours and floods.

QUATERNARY

Pleistocene gravels.—The Pliocene volcanic ejectamenta probably almost filled the Pliocene interior sea which occupied the central plains. At the close of the Pliocene, there was a period of general diastrophism which initiated the emergence or the uplift of the region resulting in the present elevation.

The elevation since the beginning of the Pleistocene must have amounted to about 165 meters, because this is the highest elevation where Alat conglomerate has been observed. However, gentle Post-Pliocene folding and faulting may have slightly elevated the conglomerate.

The highest Pleistocene terrestrial gravels were observed near Norzagaray, immediately west of Lambak at an approximate elevation of 135 meters. Pleistocene gravels generally occur as thin mantles, and sometimes as accumulations in depressions.

The next general accordant elevation of Pleistocene gravels is at about 85 meters. Around Novaliches, it is probable that the accordance of levels at an average height of 135 meters, with flat-topped ridges, is due to the original deposition of the tuff under water. Since this portion is nearer to the sea at present, it must still have been under water when the portion around Norzagaray was already land on which terrestrial gravels were accumulating.

Fossils are lacking and the division between Pleistocene gravels and recent alluvium is not sharp. The altitude of about 135 meters has been taken as a division line, because the highest gravels which clearly belong to the most recent river deposits do not exceed that altitude.

Recent alluvium.—This is found along the alluvial plains and flood plains of the present river systems, especially Angat River and Mariquina River. It is probably about 20 meters thick, and may be considerably more in many places. The barrio of Matictic is built on an alluvial flood plain which is constantly being destroyed on its eastern side by the lateral cutting of Angat River. This alluvium is made up of all kinds of river gravel with occasional lenses of sand and clay. During earlier erosion and deposition, much of the recent gravels and the Pleistocene gravels as well, at their margins near the mountains, were no doubt overlapping alluvial fans.

STRUCTURAL GEOLOGY

General.—The area under consideration is on the western flank of the Eastern Cordillera and on the eastern edge of the great central plains. The Eastern Cordillera is an anticlinorium with several intrusions of basic igneous rocks for its core. It is made up of three parallel ranges with a general north-south trend, parallel to the direction of the major tectonic lines of Luzon. The intrusions, therefore, are elongated north and south forming the backbones or cores of the Cordillera. The major structural and physiographic features are in keeping with the general tectonics of the region.

In the Angat region, the formation has a general dip to the west, although there are minor folds in the anticlinorium. This western dip is reflected in the gentler western slopes and steeper eastern slopes of the ridges and in the long westward and short eastward flowing tributaries of the river systems.

The greater part of the area was covered by the flood of Miocene lavas, thus concealing from observation many of the structural features and details of Pre-Miocene geology. This

lava plateau has been dissected, but it is still recognizable from the flat-topped hills and ridges bearing a general accordance of summits. In fact some geologists, on first seeing the region, have noted that this accordance of summits suggested peneplanation. This dissected lava plateau is now gently folded, and several faults cross it.

NOTES ON PRE-LAVA-FLOW TOPOGRAPHY AND STRUCTURE

The cherts on Ipo River about 5 kilometers from its mouth are exceedingly well stratified and the attitude was accurately determined. The strike was north 13° east and the dip 66° west. The fissured and broken-up character and the massiveness of the limestone made it difficult to determine the attitudes in different localities. At the mouth of Ipo River the probable strike is north 15° east, with a very steep dip to the west. Along the upper Angat River near Sapang Puti (locality 10) the probable strike is about north 15° east, and the dip was questionable. Among the isolated limestone outcrops surrounded by Miocene lavas, there seems to be a persistent strike of north 15° east, and a general persistent dip to the west to nearly vertical. At Montalban Gorge, the basal shales and sandstones strike north 24° east and dip 60° to 70° east on the eastern limb of the sharp anticline there. A study of the region around Montalban by Adams [21] also shows the same general attitude. Ickis,[22] crossing from Infanta to Tanay, also found the limestone sharply folded with axes about due north-south. The limestone outcrops east of Montalban follow these folds. It is evident that the cherts and the Oligocene sediments have a similarity of attitudes.

All the isolated limestone outcrops in the area fall in two more or less straight lines, trending between north 10° east to north 15° east. These limestone outcrops are the high elevations which were not covered by the Miocene lavas, although some of the outcrops were exposed only by stream cutting. Limestone, therefore, was the predominant material of the ridges in the Pre-Miocene topography just as the same limestone makes prominent ridges at present in Montalban and in the area east of Sibul, San Miguel, Bulacan. It seems, therefore, that in the pre-lava-flow topography there were clear-cut, regular, straight ridges which trended between north-south to north 15° east. Limestone, which was harder than the shales and sandstones, made up these prominent ridges. Lambak shales

[21] Op. cit.

[22] Ickis, H. M., op. cit.

and sandstones were eroded from the top of the ridges and were probably preserved in the valleys. These regular ridges and valleys were clearly due to faulting, folding, and subsequent differential erosion making prominent escarpments of the limestone.

On account of the general southerly trend of the ridges, the streams followed the depressions and flowed southward, and undoubtedly cut water graps through the ridges, because the original slope of the region was to the west. The upper course of Angat River is in the basement complex and has not been covered by basalt, so that the present upper bed was also its pre-lava-flow bed. Angat River might have been flowing southward along a north-south depression along the present lower course of Ipo River through the present Mariquina Valley, emptying into a former and greater Manila Bay. Mariquina River may have emptied into the former south-flowing Angat River. When the lava flows came Angat River may have had to seek a new channel.

Just west of this probable old course of Angat River, lies the easternmost line of isolated limestone outcrops. Angat River may have flowed between a limestone ridge and a diorite ridge, so that conditions favoring pseudo-monoclinal shifting may have obtained and a straight water course must have been established.

The relief was probably as great as the present since the lavas which flooded the region filled up the depressions thus decreasing the relief. However, these lavas have been cut into by subsequent erosion.

Folds (*Plate 3*).—All the formations except the Quaternary are more or less folded. Quaternary alluvium has undergone elevation, without signs of folding. The Pre-Miocene sediments evidence the greatest amount of folding. Since their attitudes are about the same, the supposed Jurassic cherts and the Oligocene sediments have probably undergone about the same amount of diastrophism. The Post-Oligocene formations are gently folded and undulated. In several places where the Miocene lavas show pseudostratification, folding is very evident. It was observed that folding in the lavas was more severe than in the later formations. The Alat conglomerates and the Guadalupe tuff are undulating with low, small, broad anticlines and synclines whose axes trend generally in a north-south direction, with variations within 15° east or west.

Between Bakas and Polo there is an anticline (see section along *a–a*, Plate 3) of greater dimension than the other folds,

and followed eastward by a syncline. Their axes follow more or less the general direction of the tectonic lines of the region. Clear stratification in the limestone along Angat River at Suclib (Plate 12, fig. 1) and its vicinity shows very nicely the succession of small folds in the formation, but the general attitude of all the formations is a persistent general dip to the west. At Suclib the limestone strikes north 65° west and dips 12° south. This somewhat abnormal strike is probably due to a displacement by faulting. At Bakas and Polo, the strike also varies somewhat, but it must be remembered that the limestone and shales of the Oligocene have suffered great folding and therefore variations in their attitudes should be expected. At Bakas on the western limb of the anticline, the strike is north 30° west, and the dip is 22° west. On the eastern limb, at Bologan, near Polo, the strike is north 22° east and the dip is 12° east. Suclib is on the eastern limb of the syncline.

At Montalban (see section along *d–d,* Plate 3), there is a very sharp anticline trending about north 24° east. This is well shown in the basal shales and sandstones beneath the limestone. The cross section along line *d–d* (Plate 3) shows the structure at Montalban. The big limestone outcrop there is the eastern limb of a sharp anticlinal fold across which the Mariquina River has cut through exposing the basal sediments of the Oligocene. On account of the absence of lava in the gorge it is evident that the stream had not made the gorge yet when the basalt came, but that this new channel was cut after the other drainage channels had been dammed by the basalt. Wawa Creek follows, more or less, the axis of the Montalban anticline. The strikes vary from north 32° west to north 10° east the west dips from 38° to 82°, and the east dips from 64° east to 79° east. At one place the shales were vertical.

Miocene faulting previous to the lava flows.—The great Post-Oligocene period of diastrophism, besides intensely folding the strata, may have also produced thrust faulting even before the lava flow, especially when we consider that there is a limestone member between shales and sandstones; a hard, brittle, and resistant bed between comparatively much softer and more pliable beds. However, because of the lava flood, evidences are lacking. The folding up of the limestone along Minoyan Creek and at Suclib, together with the propable thrust faulting must have made a barrier which limited the lava flow to the west.

Miocene faulting after the lava flows.—The diastrophism that began after the Oligocene must have continued until after the

lava had solidified, because there are evidences of folding and thrust faulting after the lava flow. At the base of the limestone above Suclib in the vicinity of Pared, no basal Oligocene sediments were found and the limestone is seen resting on top of the younger Miocene basalt. The basalt was clearly not intruded into the limestone, because instead of evidence of contact metamorphism there was observed a great amount of slicken-siding along the contact denoting displacement, and the basalt at the contact is greatly weathered denoting a fault contact. This thrust fault is responsible for the prominent and high limestone outcrops along Angat River and Minoyan Creek.

Besides thrust faulting, these compressive stresses must have resulted in breaks inclined to the direction of the thrust. It is, therefore, probable that cross faults 2 and 3, (see map, Plate 2) may have been initiated at this time.

Post-Miocene faulting.—Doubtless, after the compressive stresses, which resulted in the close folding and thrust faulting, were spent, a settling must have followed producing normal faults. It is possible that with the great overburden of lavas this settling was emphasized and the present normal faults in a general north-south direction resulted.

The earliest movements along fault lines occurred along the east-west cross faults, 2, 3, 5, and 6, because the long north-south faults cut these cross faults. Then followed faults 1, 4, 7, and 8 which were more or less contemporaneous (see map, Plate 2). The cross faults were probably caused by compressive stresses, and the long north-south faults by the reactionary tensional stresses after the compression.

DESCRIPTION OF THE FAULTS

THE CROSS FAULTS

Fault 2.—This fault trends about north 70° west and follows the general direction of the lower Angat River from the mouth of Ipo River. It probably has influenced the general direction of the lower courses of the river. This fault was determined in the field from the alignment of the abrupt turn of Angat River in the vicinity of Ipo River, with the remarkably straight contact line between the limestone outcrop along Angat River and the Miocene lavas. It is an abnormal contact line because the contact lines would be expected to run north-south in keeping with the structure of the region. Besides, faulted blocks have been observed on the southern bank of Angat River at the Ipo dam site. The direction of Angat River

corroborates the evidence. The northern side of the fault appears to be the downthrow side. This fault is probably not active of itself, but any movement along the long north-south principal faults may cause slight adjustments.

Fault 3.—Fault 3 cuts Ipo River at about 2 kilometers from the mouth and trends about south 72° west and follows the general direction of Osboy Creek and Santa Maria River. It meets fault 2 east of Ipo River. It was mapped on two direct evidences. At localities 40 and 44 (see map, Plate 2) Binangonan limestone covered by basalt was encountered at river bottom. At locality 44 this limestone outcrop disappears at a long fault scrap about 2 meters high (Plate 13, fig. 1) where there is a waterfall, and is displaced and continued about 40 meters higher on a ridge. The southern block is the downthrow side; the throw is about 40 meters with a heave of about 60 meters. At locality 46 (see map, Plate 2) a prominent, straight, wide fissure gap in the stream bears about south 78° west, in line with the displaced limestone at locality 44. As corroborative evidence, this fault is in the general direction of Osboy Creek and Santa Maria River.

Movements along fault 3 may only be subsidiary to displacements along the principal north-south faults which cut it.

Cross-faults 5 and 6 are only small local faults and will be discussed later with the system of local faulting in Novaliches River.

THE NORTH-SOUTH PRINCIPAL FAULTS

Fault 1.—This principal fault is a normal fault and has a north-south trend going through Biten-Biten and marks the contact line between the lavas to the east and the limestone to the west in the upper Minoyan Creek. It is marked by a prominent limestone escarpment which is straight and regular until it cuts fault 2. This fault line was extended to the north and to the south on the strength of the abrupt bends in all the streams in line with the escarpment. From the north (see map, Plate 2) the bends occur at Maasin River, Bayabas River, Sapang Balite, Minoyan Creek, the Biniakdan and Katitinga forks of Santa Maria River, Sapang Alat, and Novaliches River. Elongated hills along the fault have also been noticed. It probably joins fault 7 near the southern edge of the present area.

The downthrow side is the western side, although there are escarpments on both sides at Bicti. The western escarpment is a result of the erosion of the shales to the west which are in contact with the limestone. The eastern escarpment is due

to recession by solution of the limestone, which was either overfolded or overthrust on the basalt during the Miocene compressive stresses. The throw of the normal fault is probably small, and so is the heave, and the western block has shifted slightly to the south.

Recently the Metropolitan Water District has started operations on their proposed 7-kilometer tunnel from Bicti to the Ipo dam site. Work was begun at both terminals. The work at Bicti had advanced to more than a kilometer and the contact between the limestone and the andesite was observed closely. A vast amount of slicken-siding was noted in the limestone at and near the contact, showing conclusively that movement must have occurred along this contact.

Thus faults 1, 2, and 3 form a triangular block from which the opposite blocks on the three sides have been depressed by normal faulting.

Fault 7.—Fault 7 is probably a very long fault which marks the western side of Mariquina Valley and trends about north 20° east (Plate 8, fig. 2). North of Mariquina Valley, this fault probably limits more or less the eastern boundary of the basalt area, since it has been reported that Mount Lacotan and Mount Katitinga are made up of diorite. It is in line with a straight trenchlike depression which is very noticeable from the northern edge of Mariquina Valley (Plate 9, fig. 2). This depression passes immediately west of Mount Lacotan and Mount Katitinga and is also more or less in line with the upper courses of Angat River.

At Mariquina Valley (Plate 8, fig. 2) though the escarpment is not well preserved, the material being tuff, it is too straight to have been produced by the mere meandering and sidecutting of the river. It is at this fault trace that Mariquina River makes a right-angle turn to the south, changing its westward course to a southerly one. Moreover, the basalt flow that has its source in the vicinity of Antipolo and constitutes the ridge flanking the eastern side of Mariquina Valley, must have flooded the space occupied by the present valley to connect with the basalt area northwest of the Valley. The disappearance of the basalt in the present Mariquina Valley must be explained by faulting.

Furthermore, this fault can be traced south into Cavite by marked escarpment, even though the material is tuff, and in an alignment of unnatural abrupt bends in the streams in Cavite and Laguna Provinces. It limits the western boundary of La-

guna de Bay. The uplift of the western portion of this fault made the escarpment and is responsible for the separation of Laguna de Bay from Manila Bay. This happened after the Pliocene tuffs were deposited, and is, therefore, comparatively recent.

Fault 7 is the major structural feature in this area. The alignment, in a gentle doubly curved line, of Mariquina Valley, the upper Angat River, the straight abrupt bluff of the Pacific coast between Agria Point and Encanto Point, Casiguran Sound, and the straight Pacific coast between Dinapiqui Point and Disumangit Point may be noted. Southward it may be extended along the fault scarp west of Laguna de Bay, through Taal Lake and the eastern coast of Batangas Bay where it probably stops. This major fault line is shown in the small map of Luzon (fig. 3).

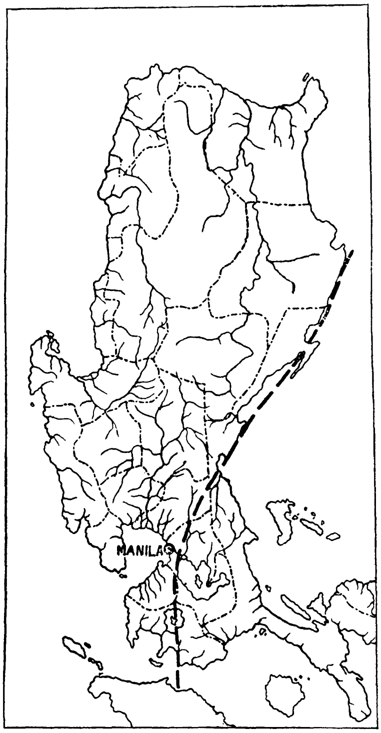

Fig. 3. Northern Luzon, showing the extension of the western fault of Mariquina Valley (fault 7).

In Mariquina Valley the latest movement along fault 7 is probably a tilting to the west of the western block.

Fault 8.—Bailey Willis said that this was the most beautifully preserved fault he had ever seen. It marks the eastern side of the graben occupied by Mariquina Valley (Plate 8, fig. 1; Plate 9). It is very conspicuous because of its prominent and excellently preserved escarpment in basalt. This escarpment rises abruptly from the alluvial plain of Mariquina River and is essentially straight. The escarpment shows faulted valleys and truncated spurs with triangular facets. It probably extends northward to Mount Oro, about 10 kilometers northeast of Montalban town. Toward the south it reaches Laguna de Bay, recurving slightly to the east, and may cross the lake into Laguna and Batangas Provinces. South and southeast of San Mateo, there is a small group of low, rounded hills of basalt

just west of the fault. These low hills represent the downthrow side of the fault. Farther north the downthrow was greater, and no traces of the basalt in the valley are seen. Farther south, the low hills of basalt show that there the throw was less. The throw in this fault must have been considerable if the level of the former lava plateau which must have covered the present site of Mariquina Valley is taken into consideration. Even if 300 meters is taken as the level of the old plateau (there are many places in this basalt range east of Mariquina which exceed this height) and 30 meters as the altitude of the floor of Mariquina Valley, the throw must have been 270 meters or more, because the alluvium is very thick. Opposite and below San Mateo, the throw must have been less. Probably this movement did not take place all at once within recent times, but began during the after effects of the great Post-Oligocene compressive diastrophism and after the lava flows had covered the region. A total throw of 270 meters or even more is not difficult to comprehend when we take into consideration all of Pliocene, Pleistocene, and Recent times. However, the conservation of the escarpment, with faulted valleys and truncated spurs, point to the recency of the greatest part of the movement.

It has been thought that the limestone ridge through which Mariquina River has cut a deep gorge, and in which the dam of the Metropolitan Water District is built, is in fault contact with the basalt on both sides. The writer is of a different opinion, because of its general alignment parallel to the axes of the normal folds of the region, and the general north-south trend of the limestone outcrops everywhere else, it seems that this limestone ridge was a prominent ridge of the Post-Oligocene pre-Miocene topography. It was very closely folded, resulting in the nearly vertical attitude of the strata. Because of its altitude it was not covered but merely flanked by the Miocene lava flows. On account of the hardness of the limestone, the comparative softness of the shales stratigraphically above it, and the close folding, this ridge, similar to the other limestone ridges of the Post-Oligocene pre-lava-flow topography, had a linear and almost straight feature. Therefore, the lava flows had a regular and almost rectilinear contact with it.

Faulting along the upper Novaliches River (*see Plate 2 and text fig. 2*).—This comparatively small and unimportant system of faulting is interesting because it shows that even small and recent faults in the subsidiary creeks of a river system can be successfully recorded. It is recent since erosion in the soft tuff

has not yet obliterated the topographic expression of this faulting. Under the topic of drainage attention has already been called to this influence of faulting on the upper courses of Novaliches River. The angularity of the pattern above Camates Creek immediately attracts attention. Novaliches River and its branch, Camates Creek, are almost parallel in this vicinity. Then Novaliches River turns an abrupt right angle and meets Camates Creek about 1 kilometer downstream, and turns to the south again. Since the formation here consists of Guadalupe tuff and tuffaceous sediments, which are only slightly inclined, it cannot be that lithologic differences had any influence on the drainage pattern. It will also be observed that the small area between Camates Creek and Novaliches River is lower than either side, and that there are more and longer tributaries to both streams from either side than from the middle area. Fault 5 is reflected east of Novaliches River by a small straight creek, but the line seems to have shifted a little to the north. Fault 6 is reflected in some turns of Novaliches River with a small escarpment as its continuation to the east. Faults 1 and 4 are probably contemporaneous and the cross faults 5 and 6, also contemporaneous and earlier. The more recent faults 1 and 4 have displaced the cross faults horizontally. The relation of the drainage and topography to faulting in this vicinity is clear and interesting. The middle area is a block which was tilted down, with its greatest movement at fault 5 and which probably amounted only to about 10 to 15 meters. In other words the movement was pivotal, with the pivot or fulcrum about 3 kilometers north of fault 5. It is, therefore, true that the system of faulting was already there before this tilting took place, and that this tilting is the most recent movement or at most contemporaneous with faults 1 and 4. This system of faulting was mapped and studied on the strength of criteria derived from the drainage pattern and the peculiar topography, and not from lithologic, structural, or other criteria. All these faults are normal faults.

Joints.—Joints are conspicuous and had doubtless influenced many of the erosional features. A few observations were taken, and free use was made of the notes on jointing by H. G. Schenck, who did some work along Angat River and in Sapang Laan, north of Montalban town.

Above the mouth of Ipo River, on Angat River, there are two predominating sets of joints, one trends northeast and the other east-west. There is an obscure suggestion of a north-

west joint which may have been due to a thrust from the west, and which may be the latest. Hartmann's law says that for brittle substances the acute angle of fractures is bisected by the greatest tension or easiest relief. Therefore, above Ipo River, where the joints trend east-west and northeast, the thrust must have come from the southwest with a bearing of about north 68° east or from the northwest, south 68° west.

In the vicinity of Paila the joints have the following dips and strikes:

1. Strike north 30° east, dip southeast, predominant.
2. Strike north 20° west, dip southwest, doubtful.
3. Strike north 25° west, dip 50° southwest, probably the same as 2.
4. Strike north-south, dip 70° west, dikes and some joints.

Set 4, which is inconspicuous, is probably due to the rotational strain produced in the flank of an anticline as a result of a thrust from west to east.

The rest are hard to explain from Hartmann's law, because then the thrust would have had to come from the north or from the south; but the folding and the structure point to a thrust from the east or west, and these joints may not be due to compression. It is very probable that these joints are tension joints because after the Middle Miocene tensional stresses have been the rule as previously explained. It is, of course, to be expected that, when the lava cooled down, contractional joints resulted, and open joints have been observed. Therefore, it is surmised that the joints due to compression are the oldest, because of the great compression of Post-Oligocene age, and the tension joints are the youngest due to the settling after the compression and the cooling of the lavas. It is also significant that the compression joints are mostly found above Ipo River beyond the area of lava flows, in basement complex rocks, and the tension joints generally in the lava area.

At Sapang Laan, according to Schenck,[23] north of Montalban, there are two sets of joints, with directions of north-south and north 30° east, similar to those at Paila. These joints are in basalt and are also probably tension joints.

It must not be forgotten that the Pliocene and later sediments are also folded, though the folding is slight. This folding must have been due to compressive stresses which probably took place some time during the Quaternary. Whether any of the sets of joints are due to this last compression or not, has not

[23] Philip. Journ. Sci. **20** (1922) 57.

been determined. At Sapang Laan, the north-south set of joints may be due to tension, or to rotational strain.

Doubtless the angular broken course of Angat River and many of its tributaries is controlled mainly by the different sets of joints. Faulting may have also helped, especially in the general direction of the rivers, but it must be remembered that faults may be defined as joints where appreciable relative displacement has taken place.

Intense, complicated, and irregular jointing or shattering has taken place in the Binangonan limestone as a result of the compressive stresses when it was folded after the close of the Oligocene. The different sets of joints are hard to understand, and this detail in structure has not been deciphered.

Dynamic metamorphism.—The Binangonan limestone is probably of an organic origin, because corals and other fossils have been observed, especially from locality 42 to locality 45 where there is a long ridge of limestone, corals and other fossils were very abundant. Because of the great compressive stresses at the close of the Oligocene, and extending into the Miocene, most of the fossils have been obliterated or at least obscured, and the limestone has become very crystalline, in some places so coarsely crystalline that the term marble might be used. In many places flat flakes of limestone about 1 inch thick and 3 to 5 inches in diameter with very good slickensided surfaces are common. These are due to the gliding between the shattered pieces during the adjustment which resulted from the great compressive stresses above mentioned.

The thin and sometimes concentric laminations of the Lambak shales, and their hardness, are also greatly due to dynamic metamorphism.

The hardness of the Jurassic (?) cherts is doubtless a result of cementation, old age, and dynamic metamorphism. Its lamination is due to its original deposition because the different laminæ are either persistently green or red. Compressive stresses have folded and jointed these cherts.

Seismologic considerations.—June 3, 1863, a disastrous earthquake occurred in Manila and its vicinity. The axis of the mezoseismic area, according to Father M. Saderra Masó,[24] followed the direction of the Eastern Cordillera.

From the map on page 280 (of Smith, op. cit.) the present area is included in the seismic region. None of the seismotectonic lines coincide even in a general manner with the faults that have

[24] Bu. Sci. Publ. 19 (1925) 285.

been studied in the area. If the axis of the mezoseismic area followed the direction of the Eastern Cordillera, which trends almost north-south, the movement could not have been along the above-mentioned lines. And since the mezoseismic area was west of the Eastern Cordillera, it could not have been due to the seismotectonic lines east of the Eastern Cordillera.

From a study of the structure of the area under consideration it seems most probable that the movement must have taken place along both faults of Mariquina Valley, faults 7 and 8. It is possible that movement also occurred along fault 1, but it was probably only subsidiary to the other faults. Of the two faults of Mariquina Valley, it has not been ascertained which is the more active because the western fault, 7, is not as clear cut as the other, but it has a much longer extension; while the eastern fault, 8, although comparatively short, has a greater inequality in balance on both sides, and its escarpment is comparatively fresh. However, fault 7 is a major structural fault, and is probably the more active.

If displacements occur in faults 7 and 8, and in consequence, also along fault 1, minor adjustments will result in the cross faults. It is possible that on account of these minor adjustments these cross faults are beneficial in that they may take up some of the movement and may minimize the shock.

Since Mariquina Valley is a graben where sediments are gradually accumulating and the regions on both sides are constantly being denuded; and since these faults here are very recent, it is only to be expected that movements should occur along them at present. Being normal faults, with probably little or no horizontal heave, the shocks imparted will have two components, one vertical and the other horizontal at right angles to the fault traces, or in a direction between north 60° west and north 70° west.

Minor adjustments along fault 1 may result in a horizontal oscillation with a general north-south direction, because it is believed that in fault 1, a horizontal north-south displacement along the fault trace has occurred. However, these shocks should not be as marked as the others.

GEOLOGIC HISTORY

Since the oldest sediments are the probable Jurassic (?) cherts and the next oldest are the Oligocene sediments, the geologic history of this region which can be read from the records accessible to mankind will be comparatively short and recent.

However, an attempt will be made to decipher the history contemporaneous with the intrusions of the granite and the old basement complex rocks. All that is certainly known regarding these rocks is that they are older than the Jurassic, and that the granite is the oldest rock.

PRE-TERTIARY HISTORY

Paleozoic times.—During Pre-Permian times, the Philippine Islands were at the very edge of the broad continental shelf of Asia. The South China Sea basin had not yet been depressed. On account of its great distance from the mainland of Asia, Paleozoic sediments may not have reached the edge of the continental shelf, except, in all probability, a small amount of extremely fine clastics. It was too far from land, and probably too deep for littoral faunas. This explains the absence of recognizable Paleozoic sediments and fossils.

The intrusion of granite.—Sometime during the early Paleozoic, there were small local stock intrusions of granite and other allied rocks, and a small amount of grano-diorite. Some of the magma may have reached the surface, or near the surface, because samples of rhyolite have been collected. In all probability these rhyolites were, therefore, extruded under water. One of the localities intruded by these acid rocks is the granite area in Bulacan Province. There was a slight up-bowing or doming of the crust which probably slightly affected parts of the Angat River area, especially north of the river. The Philippine Islands were still under water and did not yet have the present configuration.

The Permian revolution.—Paleontologic evidence points to the existence of the South China Sea during Triassic times. If this is true, then the basement complex basic rocks, which form the backbone and the framework of the structure of the Philippine Islands, must have been intruded before the Triassic because the Philippine Islands is the barrier that cuts off the South China Sea from the Pacific. As the closest and most probable period of diastrophism before the Triassic is the great world-wide diastrophism during the close of the Permian, it is extremely probable, that it was during this time that the depression of the South China Sea basin occurred with a contemporaneous intrusion of basic rocks in the area now occupied by the Philippine Islands. If the thrust resulted from the depression of the basin of the South China Sea, then we should expect the crust to have been folded along a north-south axis,

and the intrusion to be elongated in the same direction. Since we have no Paleozoic sediments, the Permian or Pre-Triassic folds could not be observed, but the areas of coarse basic rocks are elongated north-south. Therefore, it is very probable that during the Permian diastrophism, the South China Sea was depressed, the basement complex rocks of the Philippine Islands were intruded, with their associated hypabyssal and extrusive equivalents, and the present configuration of the Philippine Islands was outlined, as far as the skeleton and frame work is concerned. However, even if the Philippine Islands formed a barrier for the South China Sea, they had not yet been elevated above the water. This is in keeping with the belief that the principal mountain ranges of the East Indies, Java, Sumatra, Borneo, etc., were formed also at this time.

MESOZOIC

Deposition of the Baruyen cherts.—At the beginning of Mesozoic times, therefore, the South China Sea was already a basin isolated from the Pacific Ocean by the elongated batholithic intrusions of the basal complex rocks of the Philippine Islands. The area of the Philippines was probably still too deep for corals or other shallow-water fauna to flourish. No coarse sediments of the Mesozoic have been discovered. The probable Jurassic cherts are the only recognized Pre-Tertiary sediments, and they have very poor and very limited outcrops. Consequently detailed sections are quite impossible. Smith[25] has called the cherts the Baruyen cherts in Ilocos Norte, to which a probable Jurassic age has been assigned. There are two phases of this chert as heretofore explained under Stratigraphy. One is red chert or jasper, which contains fine angular grains of feldspar and some quartz embedded in the red hematitic and opacitic semicrystalline silica. In these red cherts radiolarian tests have been found by Smith and by the writer.[26] The other phase is a green chert which owes its color either to chlorite or to glauconite. It is very fine microcrystalline chalcedonic or opaline silica, and feldspar grains are very rare. No radiolarian tests were observed in this green chert. These two phases of the chert alternate irregularly in the beds. It is probable that the red cherts were deposited in times of great devastating floods in the mainland of Asia, carrying in their turbulent waters the fine sediments. It is significant that these cherts have not been

[25] Op. cit. 72. [26] Loc. cit.

found in the eastern part of the Philippine Islands. It is also probable that during those times there was a greater mortality among the radiolarians. The green chert may be ascribed to deposition during quiet and peaceful times.

These probable Jurassic cherts are the only Mesozoic sediment found. Doubtless there should have been sea deposits during the Triassic. There is the great probability that these cherts represent not only the Jurassic, but also the Triassic, and the Camanchean—probably all of Mesozoic times before the intrusion of the ultra-basic rocks which probably occurred during the Cretaceous. This statement is merely suggested to fill the gap in the geological history of this region, because there are no records except the Baruyen cherts. Under this hypothesis, the Philippines had not yet emerged above the sea.

Intrusion of the peridotites and pyroxenites.—In Zambales, Elicaño [27] found hornblendite intrusive into the cherts. Smith[28] says that in Ilocos Norte and other parts of the Archipelago pyroxenites and serpentinized rocks probably belong to the part in the column that is intrusive into the Mesozoic sediments. It is very probable that during the Mesozoic, after the deposition of the cherts, the third great intrusion occurred, and its predominating rocks were pyroxenites and peridotites. It is true that this intrusion could have occurred at the end of the Mesozoic or even during Eocene times. A study of the composition of the Agno conglomerates, in Baguio and its vicinity, which are supposedly Eocene, might solve this problem. However, among the geologists who attended the Third Pan-Pacific Science Congress at Tokyo in 1926, there is a concensus of opinion that the ultra-basic intrusion which happens to be general from Japan, through the Philippines and the East Indies to New Zealand, occurred during the Cretaceous.

The close of the Mesozoic.—Great, world-wide, epeirogenic movements brought the Mesozoic to a close. These great continental uplifts changed sea bottoms to dry land. They inaugurated Tertiary geologic history, and for the first time the Philippine Islands emerged from the water. It was the dawn of erosion.

TERTIARY

The absence of Eocene sediments.—In the area under discussion no Eocene sediments have been observed, but in Baguio and its vicinity the Agno conglomerates, of probable Eocene

[27] From field notes of V. Elicaño, Bureau of Science, Manila.
[28] Bu. Sci. Publ. 19 (1925) 76.

age, are present. These conglomerates indicate the existence then of islands of moderately high relief. The absence of Eocene sediments in the Angat-Novaliches region may be due to one of several causes. The area may have been land and the Eocene sediments never deposited; or, if they were deposited, they may have been eroded off or covered by the later sediments. It is probable that the area of the Eastern Cordillera was suffering erosion while deposition was being made on its flanks. The land continued to be uplifted, and whatever Eocene sediments may have been deposited, subsequent erosion after exposure may have obliterated them. More-extensive Eocene sediments, therefore, might be encountered under the epicontinental sea of the Philippine Islands, because there was a greater land area near the close of the Eocene that at present or any other time. The basis for this opinion is as follows. Oligocene coal strata in Mindoro and Batan can be correlated between islands. The coal seams in Bulalacao, southeastern Mindoro, cross over to Semirara Island, and the coal seams in Albay cross to Batan Island, and are exposed at the sea shores. To have a coal deposit, lagoons or swamps wholly or nearly surrounded by land is necessary since coal cannot be deposited in the open sea. Therefore, the land must have been more extensive then than to-day. These coal strata are of lower Oligocene age and above these we have the Oligocene limestone. A gradual subsidence of the Islands was in progress at the beginning of the Oligocene.

THE OLIGOCENE

After a long period of erosion during the continued uplifting of the Eocene times, the upward movement was reversed, bringing the Eocene to a close and inaugurating the Oligocene. From that time, the history of this area is based on substantial evidences, since there are representative deposits of the Oligocene and all ensuing epochs.

First, of course, the basal Oligocene conglomerate was deposited. This was very thin and may indicate a rapid subsidence of the land. Then the thin layer of lignite, found near Matictic, was laid down at a time when the land was oscillating near sea level, and the downward movement was either temporarily arrested or became slower and more gradual. Associated with the coal, the dark, unfossiliferous shales of the Lower Oligocene were deposited. Most of the coal seams in the Philippine Islands were laid down at this time. Then the region continued to sink. The water must have been clear and warm when the Binangonan limestone was deposited, as

it contains coral, *Lepidocyclina, Lithothamnium ramosissimum,* and other fossils. Toward the close of the deposition of the limestone, and during the earlier deposition of the Lambak shales, the Philippine Islands experienced the greatest submergence since they were uplifted from the sea. Toward the latter part of the Oligocene, conditions must have changed, and the Lambak shales and sandstones were deposited. An upward movement had then been initiated resulting in a shallower sea, and coarser clastics were deposited. The comparatively hard greenish Lambak shales were probably deposited when the sea bottom was still relatively deep, because they are very fine sediments, and the green color is due to either chlorite or glauconite. The coarser clastics, as the sandstones and the tuffaceous sandstones, were the last of the Oligocene sediments to be deposited. The tuffaceous sandstones imply minor volcanic activity during the latter part of the Oligocene.

THE MIOCENE

Post-Oligocene or Miocene diastrophism.—The Oligocene was brought to a close by the greatest diastrophism in Tertiary times ever experienced by the Philippine Islands, and which lasted till the end of the Miocene. The attitude of the oldest sediments, the Baruyen cherts, is very similar to that of the Oligocene sediments. Consequently it is improbable that the cherts had been disturbed by any appreciable orogenic movements before this time. Great compressive stresses from the west folded the Oligocene and older sediments into very sharp anticlines and synclines trending about north-south to north 30° east. Locally, these folds lifted the land out of the water. Thrust faulting may have resulted from this thrust from the west making prominent bluffs of limestone. The direction of faults 2 and 3 point to a possibility that they were inaugurated during the compressive stresses, and that they may be ruptures inclined to the direction of compression. A moderately long period of erosion set in during the lower Miocene which etched the topography. The limestone, being harder than the rest of the Oligocene sediments, stood out as more or less straight and regular ridges, the crests of the sharply folded anticlines. The general slope of the region was to the west, but the streams flowed in a general southerly direction, due to the limestone ridges. Doubtless, water gaps were cut across these ridges. Angat River probably flowed southward into the former and larger Manila Bay, and Mariquina River may have emptied into this older Angat River.

Lava flows.—The Miocene dawned on a land area which was being subjected to great compressive stresses and at the same time was suffering fast tropical weathering and erosion. It must be remembered that this diastrophism continued until after the Middle-Miocene lavas had been extruded, but it is believed that it was strongest at the outset.

Miocene sediments, whether terrestrial or marine, have not been found in this area. Volcanism, in the form of lava flows, played the principal rôle during this phase of the history, in the Middle Miocene. It flooded a land area of mature topography carved during the Lower Miocene.

The first lava flow was a basalt which gathered and included in it the alluvial material made and deposited by the Lower Miocene rivers (fig. 22). The term volglomerate has been proposed for this type of flow. Former geologists have all noted this formation and they have termed it, "volcanic agglomerate," "andesitic agglomerate," and "basaltic agglomerate," but it is not truly an agglomerate because of the heterogeneity of the included material, which is very different from the including or surrounding basalt matrix. Besides, the included material is generally rounded, and not angular. This first flow must have flowed in fingerlike tongues up the valleys, between the ridges.

The next lava flow is the Antipolo basalt proper, which may have been just a later phase of the first flow. This flow probably originated from the region just north of Antipolo, because the altitudes of the basalt there reach 400 meters, or more. The basalt range just east of Mariquina Valley also approximates this height, being close to its probable source. At or near Angat River, the basalt rarely exceeds 300 meters in height. This second flow almost covered the whole region under discussion. Only the higher basement complex ridges and some of the higher portions of the limestone ridges were not covered. This flow was limited in its spread by the limestone ridges and bluffs near Paila and along Minoyan Creek. At the eastern portion it was limited by the diorite ridge along the major fault 7. Toward the west it deployed, and due to the absence of obstacles, it must have spread far and wide with consequent thinning and low elevations.

The third and last flow was the porthyritic Mariveles andesite. This andesite is now found only along a comparatively narrow belt on the western part of the lava area, and is not very thick. No evidence has been found pointing to its source, but

the highest altitude at which it is found is less than 200 meters and its source must have been lower than the source of the basalt, and probably from a different vent. Andesite has been reported east of Mariquina Valley, but the relationships are not known by the writer.

These flows, of course, dammed the rivers of that time and the water had to seek new channels. The weight of the basalt must have caused added displacements in the normal faulting which occurred after the compressive stresses were spent. The cooling of the lava also caused contractional or tensional stresses which resulted in joints and which later helped the movements in the normal faults. The rivers, in their search for a waterway, took advantage of these faults and joints. This explains why the faults have influenced so much the general directions of the rivers; their minor zigzagging or broken-line courses were controlled mainly by the jointing.

Mariquina River may not have been flowing through its present limestone gorge, but due to the lava damming its old course, it cut a gorge through the limestone ridge, which was not as hard, and was full of fissures and solution cavities.

The graben of Mariquina Valley was formed when tensional stresses prevailed, although its latest movements must have occurred within Recent or Pleistocene times.

The Miocene may be summarized as an age of great volcanic extrusions.

Miocene intrusions.—In the Angat iron-ore district, north of Angat River, the instrusions which brought up the magnetite and hematite deposits occurred during the Miocene, because Binangonan limestone was intruded and metamorphosed by it. A section of this limestone was observed under the microscope. It contains the *Lepidocylina* found in the Binangonan limestone and is clearly intruded by the basic magnetitic magma. These intrusions are probably contemporaneous with the Miocene lavas, which are characterized also by a great amount of magnetite disseminations. They may be the intrusive and extrusive equivalents of the same magma.

THE PLIOCENE

After a comparatively short period of erosion of the Miocene lava plateau, the Pliocene was inaugurated by a gradual subsidence of the land and a consequent spreading of the seas. This submergence was not as extensive as the Oligocene, and in the area under discussion its farthest encroachment is more or

less outlined by the eastern contact of the Pliocene Alat conglomerates. The Alat conglomerates were deposited on a sinking littoral area, and do not exceed 35 meters in thickness. These basal conglomerates gradually grade into the finer clastics, tuffaceous sediments, and andesitic tuffs of the Guadalupe tuff formation, which was laid in a shallow-water area. This tuff forms a blanket which more or less covers the whole of the Central Plain, but for the Quaternary alluvium. Its thickness varies and may reach more than 300 meters, but in the area under consideration it probably does not exceed 130 meters.

This great amount of tuff marks the Pliocene as a period of great volcanic explosions. No Pliocene lava has been encountered. Several volcanoes around as well as those in the Central Plain must have contributed to this extensive tuff deposit. Most of the ejecta that fell on land was carried to the sea by running water.

The tuff must have almost filled the shallow-water basin in the Central Plain before a gradual emergence or uplift began that has continued, in spite of oscillations of greater or less degree, to the present time. This marked the close of the Pliocene. Slight folding occurred with emergence causing the gentle undulation of the Pliocene deposits.

THE QUATERNARY

The quaternary is largely a history of emergence and erosion, a continuation of the interrupted erosion of the late Tertiary, and its consequent gradual rejuvenation.

On account of the gradual emergence since the close of the Pliocene to the present time, it is not possible to differentiate between Pleistocene gravels and Recent gravels. The highest altitude at which the Alat conglomerates are now found is about 165 meters. This probably was the relative level of the Pliocene sea at its greatest extent; thus, we may take 165 meters as the elevation since then to the present.

Around Novaliches the highest altitude of 135 meters is made up of well-stratified tuff, with little or no alluvial material at the summits of the flat hills with accordant levels. This portion may have been uplifted from under the water and not formed by alluviation. It is only to be expected that the portion toward the south would have been the last to emerge.

During the Pleistocene or Recent movements again occurred along the fault lines, and fault 7 became active. The Guadalupe tuff on its left side was uplifted and tilted upward, ac-

complishing the separation of Laguna de Bay from Manila Bay. This movement probably amounted to 35 meters or more. Movements along all the other faults occurred also, cutting into Pliocene sediments. Along fault 8 the escarpment is so well preserved that recent movements cannot be denied.

Erosion continued, and the Miocene lava plateau is already well dissected, but its remnants are still so conspicuous that geologists who have visited the region have often suspected peneplanation.

ECONOMIC CONSIDERATIONS

The Montalban reservoir.—At present the water supply of the City of Manila comes from the Montalban reservoir (Plate 1; Plate 19, fig. 1). A dam was built across the Mariquina River at the gorge where the river cuts through limestone. The water is piped to the concrete reservoir at San Juan, where the water is treated with calcium hypochlorite and distributed to the public. During the dry season the reservoir at Montalban almost always goes dry and Manila suffers a shortage of water. To remedy the shortage of this important commodity, the Metropolitan Water District has started operations on the Angat project.

The Angat water project (*Plate 4*).—It is proposed to dam Angat River, just below the mouth of Ipo River (Plate 15), to give Manila an adequate water supply. Angat River has a much greater watershed than Mariquina River and during the dry season, when its flow is smallest, there is more water than would be needed to supply Manila for many years to come. Of the 1,300 gallons per second at its smallest flow (the drought of 1912), only about 300 gallons per second will be needed to insure Manila against any water shortage. From the proposed Ipo dam, the water will be conveyed through tunnels and pipes to the Novaliches reservoir.

The Novaliches reservoir (*Plate 16*).—This reservoir is the watershed of Novaliches River above La Mesa. It is a natural reservoir made by river erosion in the uplifted Pliocene terraine of Guadalupe tuff. By the construction of an earth dam across Novaliches River at La Mesa, a large artificial lake will be created. This dam, which consists of an earth embankment, has already been constructed.

After this reservoir is put in operation, it will temporarily aid the Montalban reservoir with the water collected in the Novaliches watershed above the dam and will materially help

in tiding over the dry season. When the Ipo dam and the water line from there to Novaliches reservoir are constructed, the Montalban reservoir will be abandoned. From the Novaliches reservoir, the water will be piped through the Payong aqueduct to sand filters where the existing pipe line from Montalban is met. From there, the old pipe line will be utilized to convey the water to the San Juan reservoir where it is treated with calcium hypochlorite before distribution.

There was some difficulty in the construction of the dam at La Mesa, Novaliches, on account of the great porosity of the Guadalupe formation. Even the fine tuffaceous shales are very porous, and sandstone layers abound. It is feared that seepage will be great.

The water of Angat River has been analyzed chemically and bacteriologically, and found to be excellent, even for drinking purposes.

Other geologists and engineers have been at work along Angat River in conjunction with this water project. Two dam sites were proposed, one at Pared or Paila (Plate 6, fig. 2) and the other one at the Ipo dam site. The Pared dam site is much narrower, but the water is much deeper. At the Ipo dam site the river is wider, but it is very shallow. Both dams are in basalt. The Ipo dam site has definitely been decided upon. Plate 3 shows the aqueduct from the Ipo dam site to the Novaliches reservoir and from there to the filters.

Power.—The enormous quantity of water flowing through Angat River at once suggests the idea of harnessing this water power. This was the the idea of the late Assistant Manager of the Metropolitan Water District, Federico Muñoz.[29] He proposed to build a power plant in conjunction with the dam for the water-supply project.

Artesian wells.—Due to an absence of impervious capping many artesian wells in the lowlands in the western part of this region are pumping wells. The wells are in Guadalupe tuff, which is so porous that there is always sufficient water in the rocks. An appreciable dip in this formation, however, helped by some sort of local capping has given rise to some flowing wells. But it is hard to explain why most of the wells in the

[29] Preliminary Report on the Angat River Water Supply and Hydroelectric Power Development, Metropolitan Water District publication, Manila (1921).

plains of Bulacan are flowing wells, since many of them are either in alluvium or in delta sediments.

Adobe stone.—At Santa Maria, Balintawac, Novaliches, and other places, the volcanic tuff of the Pliocene Guadalupe formation is quarried for building stone. It makes a very popular and cheap material for construction. It is quarried near the surface, and the excavations seldom reach a depth of 2 or 3 meters, on account of the ground water which fills them.

Road metal, sand, and gravel.—Basalt and andesite for road construction could probably be quarried profitably in several places. From favorable localities near Montalban and on Angat River basaltic material could be transported on rafts. Sand and gravel are abundant along the lower course of Angat River and Mariquina River. However, because of the presence of much basaltic material, this sand and gravel are not ideal for concrete work on account of the great amount of ferromagnesian minerals.

LIMESTONE

Lime.—The name of the barrio Apogan means limekiln. The people from there say that many years ago, limestone, which was obtained from the outcrop along Minoyan Creek, only about half a kilometer away, was burned for making lime.

Near the reservoir at Montalban on the northern side of the river limestone was burned in two or three places. The burning used to be done in small primitive open kilns and the production was very limited. Recently, however, a modern plant has been installed by the Philippine Lime Corporation. This plant has the advantage of the road to the reservoir; and production is going on at full blast.

Building purposes.—The limestone in Montalban Gorge has been utilized in making the gate house and the Montalban dam. It makes a strong and beautiful construction material. However, the limestone here is so badly broken up that production on a large scale would be problematical. At Bakas, above Matictic, the limestone is very massive and very white, but the outcrop is so small that it would not pay to quarry it.

Guano.—There are many caves in the limestone, especially along Minoyan Creek, Angat River, and at Montalban Gorge. Small quantities of guano are obtained in these caves from time to time.

Coal.—A small thin seam of lignite has been discovered in the black shales near Matictic, but it is of little or no economic importance. The discovery of good seams of fair coal would

be welcome in this region to aid in the development of the iron deposits of Bulacan, since coal is essential in the iron industry. Some lignite seams have also been reported in the vicinity of Montalban Gorge,[29] and along Puray River.

Gold.—Gold has been reported from the alluvium of Angat River and Mariquina River but in such small quantities that its exploitation would not pay. At Mariquina River an attempt was made at dredging, but it was not successful. At San Jose del Monte, Bulacan, gold is being recovered from the river gravels by means of cradles. The designs for these cradles were supplied by the division of geology and mines, Bureau of Science.

RÉSUMÉ

1. Granite is the oldest known rock in the Philippines and is probably Paleozoic.

2. The basement complex rocks were intruded during the close of the Paleozoic giving the Philippine Islands their general delineaments under the sea, and this was contemporaneous with the depression of the basin of the South China Sea.

3. The third intrusion consisting of pyroxenites and serpentines occurred after the Jurassic and before the Eocene, that is, during the Cretaceous.

4. The Eocene was a period of wide-spread emergence when the Philippine Islands had the greatest land area in their history. This was the first time that the Philippine Islands were above the water.

5. The Oligocene was a period of submergence, which was the greatest since the Islands emerged. There was also slight volcanic activity.

6. The Binangonan limestone and the sediments conformably below and above it are of Oligocene age.

7. The greatest deformation suffered by the Philippines occurred at the close of the Oligocene and extended through the Miocene.

8. The compressive stresses of the Post Oligocene-Miocene deformation was due to a thrust from the west, producing in the Angat-Novaliches region, thrust faulting, and intense folding with axes trending in a general north-south direction; they also initiated the cross faults 2 and 3. These compressive

[29] Becker, B. F., Report on the Geology of the Philippine Islands, 21st Ann. Rept. U. S. Geol. Surv. (1899–1900) 84.

stresses persisted to the end of the Miocene but were probably strongest at the outset.

9. The principal north-south faults were initiated during the settling after the compressive stresses were spent, probably during the Pliocene or Quaternary. The overburden of lava has added greatly to these settling adjustments which may persist to the present day.

10. Erosion to maturity occurred before the extrusion of the lavas when the Angat River may have flowed southward to the older and larger Manila Bay.

11. The Miocene was the age of volcanic extrusions resulting in a lava plateau. Intrusions also occurred just north of this area giving rise to the iron deposits of Bulacan.

12. The Pliocene was a period of submergence and of great volcanic explosions, which resulted in thick, stratified, tuff deposits.

13. There is a thin littoral conglomerate, with cross-bedding and local unconformities at the base of the Pliocene.

14. The Pleistocene was initiated by an upward movement which has continued with oscillations to the present time, amounting to an uplift of about 500 feet.

15. Fault 7 is a major structural feature and can be traced topographically from Batangas Bay to the northeastern Pacific coast of Luzon, and is responsible for the separation of Laguna de Bay from Manila Bay.

16. Mariquina Valley is a graben.

BIBLIOGRAPHY [33]

ABELLA Y CASARIEGO, ENRIQUE. Ligera reseña de la minería de las Islas Filipinas. Madrid, Tello (1883) 15 pp.

ABELLA Y CASARIEGO, E., et al. Estudio descriptivo de algunos manantiales minerales de Filipinas, etc. Manila, Chofré (1893) 8°, 150 pp.

ADAMS, GEORGE I. Medical survey of the town of Taytay; geology and water supply: Philip. Journ. Sci. § B 4 (1909) 211–214.

ADAMS, G. I. Geologic reconnaissance of southwestern Luzon: Philip. Journ. Sci. § A 5 (1910) 57–116; *rev.* Far Eastern Review 9 (1911) 310–314, 322, 323.

ANTON, MANUEL. Exposición de Filipinas (Madrid 1887), iii. Geología; IV. Mineralogía. El Globo, Madrid (1887).

ARAGÓN, ILDEFONSO DE. Descripción geográfica y topográfica de la isla de Luzón o Nueva Castilla. Con las particularidades de las diez y seis provincias o partidos que comprendo. Manila, Memije (1819–1821) 4°, mapas 6.

[33] Derived from G. F. Becker, op. cit; W. D. Smith, Geology and Mineral Resources of the Philippine Islands (1925); H. G. Ferguson, manuscript; and some additions by the author.

BARCO, JOSÉ DEL. Descripción de la mina de hierro de los montes de Camachin, en la provincia de Bulacán, en la isla de Luzón. M. Arenas, Rafael Diaz; memorias históricas y estadisticas de Filipinas (1850).

BECKER, GEORGE F. Brief memorandum on the geology of the Philippine Islands: U. S. Geol. Surv. 20th Ann. Rep. (1899) 8°, pt. 2, 3–7.

BECKER, G. F. Report on the geology of the Philippine Islands: U. S. Geol. Surv. 21st Ann. Rep. **3** (1901) 493–644, 2 maps, 1 pl., followed by "Concerning tertiary fossils in the Philippines," by K. Martin (translated by Becker).

BUREAU OF SCIENCE (Manila, P. I.) PRESS BULLETINS. Bull. 11. Geological examination of the northern portion of Pangasinan, Luzon. (Issued July 17, 1911.)

CENTENO et al. Memoria descriptiva de los manantiales mineromedicinales de la isla de Luzón. Madrid, Tello (1890) 8°, 117 pp.; *also* Bol. de la Com. del Mapa Geol. de España **16** (1889) 121 pp.

COX ALVIN J. Volcanic tuff as a construction and a cement material: Philip. Journ. Sci. § A **3** (1908) 391.

DALBURG, FRANK A. The iron industry in 1911: Min. Resources P. I. for 1911 (1912) 39–41.

DALBURG, F. A. Iron industry in 1912: Min. Resources P. I. for 1912 (1913) 35–37.

DALBURG, F. A. The coal resources of the Philippine Islands: The coal resources of the world. An inquiry made upon the initiative of the Executive Com. of XII International Geological Congress, Canada, 1913, 8°, Toronto **1** (1913) 107–123.

DALBURG, F. A., and W. E. PRATT. The iron ores of Bulacan Province, P. I.: Philip. Journ. Sci. § A **9** (1914) 201, 6 pls., 1 map; *ex* Min. and Sci. Press **109** (1914) 859.

DICKERSON, ROY E. A fauna of the Vigo group, its bearing on the evolution of marine molluscan faunas: Philip. Journ. Sci. **18** (1921) 1–21, 2 pls.

DICKERSON, R. E. Review of Philippine Paleontology: Philip. Journ. Sci. **20** (1922) 195.

DICKERSON, R. E. The development of Baguio Plateau: A study in historical geology and physiography in the tropics: Philip. Journ. Sci. **23** (1923) 413.

DICKERSON, R. E. Tertiary paleogeography of the Philippines: Philip. Journ. Sci. **25** (1924) 11.

DRASCHE, RICHARD VON. Ausflüge in die Vulcangebiete der Umgegend von Manila: Verhandlungen der k.-k. geologischen Reichsanstalt, Wien (1876) 8°, 89–93.

DRASCHE, R. VON. Aus dem Süden von Luzon: Verhandlungen der k.-k. geologischen Reichsanstalt, Wien (1876) 8°, 251–255.

DRASCHE, R. VON. Einige Worte über den geologischen Bau von Sud-Luzon: Mineralogische Mittheilungen gesammelt von Gustav Tachermak. Wien, Holder (1876) 8°, 157–166; *also* as supplement to k.-k. geologische Reichsanstalt, Jahrbuch **26** (1876).

DRASCHE, R. VON. Fragmente zu einer Geologie der Insel Luzon (Philippinen), etc.; Vienna, Gerold's Sohn (1878) 4°, 99 pp., 5 pls. (incl. 2 maps); translation. Datos para un estudio geológico de la Isla de

Luzon (Filipinas): Bol. de la Com. del Mapa Geol. de España, Madrid 8 (1881) 269–342.

DRASCHE, R. VON. Ueber palaeozoische Schichten auf Kamtschatka und Luzon: Neue Jahrb. f. Mineral, etc., Stuttgart (1879) 265–269.

EDDINGFIELD, FRANK T. Microscopic study of the Bulacan iron ores: Philip. Journ. Sci. § A 9 (1914) 263.

FANNING, PAUL R. Geologic reconnaissance of northwestern Pangasinan: Philip. Journ. Sci. § A 7 (1912) 255–281, 4 pls., 1 map.

GOODMAN, MAURICE. Report upon the Bulacan iron industry: Sixth Annual Report of the Chief of the Mining Bureau, Manila (1905) 48–56, Exhibit D.

GOODMAN, M. Notes on the Manila lime supply: Far Eastern Review 4 (1907) 216.

HERRMANN, RAPHAEL. A theory on the formation of the Central Luzon Plain: Philip. Journ. Sci. § A 6 (1911) 311–332.

ICKIS, HENRY M. Report on building stone near Manila: Sixth Annual Rep. of the Chief of the Mining Bureau, Manila (1905) 56–66, 1 map.

ICKIS, H. M. A geological reconnaissance from Infanta, Tayabas, to Tanay, Rizal: Philip. Journ. Sci. § A 4 (1909) 483–488.

ICKIS, H. M. The petrography of some igneous rocks of the Philippines: Philip. Journ. Sci. § A 5 (1910) 155–170.

ICKIS, H. M. Igneous Rocks, Wiley 2 (1913) Philippine Islands, 616–619.

JAGOR, FEDOR. Travels in the Philippines. London (1875) 370 pp. (Translation with some omissions of Reisen in den Philippinen.)

KARRER, FELIX. Foraminiferos de las margas terciarias de la isla de Luzón (Filipinas); Bol. de la Com. del Mapa Geol. de España 7 (1880) 257–282, 2 pls. *See* Drasche.

KEMP, JAMES F. Iron ore reserves of the Philippines: Iron ore resources of the world 2: 985 and 986. Centralryckeriet, Stockholm (1910).

KING, ALBERT E. W. The pozzuolanic properties of Meycauayan volcanic tuff: Philip. Journ. Sci. § A 11 (1916) 19–34.

KOTO, B. On the geologic structure of the Malayan Achipelago: Journ. College Sci. Imp. Univ. Tokyo 11^2 (1899) 83–120, 1 map.

MARCHE, ALFRED DE LA. Lucon et Palouan, six annèes de voyage aux Philippines. Paris, Machette (1887) 8°, 398 pp. 2 maps.

MARTIN, KARL. Ueber tertiäre Fossilien von den Philippinen: Samm. des geol. Reichs-Museums in Leiden 5 (1896) 8°, 52–69, 2 cuts. *See* Becker.

Orbitoides von den Philippinen: Centralbl. f. Mineral., Geol., 8, Palaeon. (1901) No. 11.

MASÓ, M. SADERRA, S. J. La Seismologia en Filipinas. Manila (1895) 124 pp., 50 pls.

MASÓ, M. S. Report on seismic and volcanic centers in the Philippine Archipelago. Manila (1902) 8 pp., 4 pls.

MASÓ, M. S. Volcanoes and seismic centers of the Philippine Archipelago: Census of the Philippine Islands, 1903. Washington 1 (1904) 8°, 184–254, 8 pls.

MASÓ, M. S. Las grandes profundidades del oeste del mar Pacífico y los terremotos. "Ibérica" Tortuosa, Año I, 1^{34} (1914). (The Philippine Deep.)

MASÓ, M. S. General catalogues of Philippine earthquakes: 1599–1889: La seismologia en Filipinas; 1889–1907: Bull. Weather Bureau, Manila (January to December, 1908); 1908–1909: Bull. Weather Bureau, Manila (December, 1909) Appendix. (1910– : Bull. Weather Bureau, Manila (December, 1909).

MASÓ, M. S., and W. D. SMITH. The relation of seismic disturbances in the Philippines to the geologic structure: Philip. Journ. Sci. § A **8** (1913) 199–233, 3 pls.; *See* Bull. Seism. Soc. Am. **3**[4] (1913) 151–186, 1 pl.

MCCASKEY, HIRAM DRYER. Report on a geological reconnaissance of the iron region of Angat, Bulacan: Min. Bur. Bull. Manila (1903) 3, Vol. 2, 62 pp., 42 pls., 6 tables, 1 map; *also* Far Eastern Review **1**[1] (1904) No. 2, 20–25; No. 3, 17–22; Eng. and Mining Journ. **76** (1903) 736.

MCCASKEY, H. D. The caves and mineral springs of Bulacan: Far Eastern Review **1**[7] (1904) 36–41.

MUÑOZ, FEDERICO J. Preliminary Report on the Angat River Water Supply and Hydro-electric Power Development. Metropolitan Water District publication (1921).

NIETO AGUILAR, JOSÉ. Colonización de Fililpinas; . . . ; reseña geográfico-geológico-minera de las mismas . . . con un prólogo de Arístides Saenz de Urraca. Madrid, Alonso **12** (1893) 8°, 414 pp. Part 2: Geografía descriptiva. Geológico minera del archipélago.

OEBEKKE, K. Beiträge zur Petrographie der Philippinen und die Palau-Insel: Neue Jahr. f. Mineral. etc., Beilage-Band I. Stuttgart, Koch (1881) 8° 451–501; *also* E. Schweizerbart'sche Verlagshandlung, 1–51.

PRATT, WALLACE E. The Bulacan iron-ore resource: Min. Resources P. I. for 1913 (1914) 21–31.

PRATT, W. E. The location of artesian wells in the Philippine Islands from a geologic viewpoint: Philip. Journ. Sci. § A **10** (1915) 231–240.

PRATT, W. E. Philippine lakes: Philip. Journ. Sci. § A **11** (1916) 223–240.

PRATT, W. E. Iron ores of the Philippine Islands: Am. Inst. Min. Eng. Bull. **110** (1916) 247–262.

RENARD, A. F. Rocks of the Philippine Islands: Scientific results of H. M. S. Challenger, 1873–1876. Physics and Chemistry 2, pt. 4, 160–175. London (1889) 8°.

RICHTHOFEN, FERDINAND VON. Vorkommen der Nummulitenformation in den Philippinen: Zeitschr. de deutschen geol. Ges. **14** (1862) 357–360.

ROTH, JUSTUS. Ueber die geologische Beschaffenheit der Philippinen: F. Jagor, Reisen (1873) 333–354.

ROTH, J. Constitución geológica de Filipinas: Jagor's Viajes por Filipinas, Madrid (1875) 349–373. Spanish translation of the above. Incomplete English translation.

SCHENCK, HUBERT G. Drainage control by jointing in Angat district, Bulacan Province, P. I.: Philip. Journ. Sci. **20** (1922) 57.

SEMPER, CARL. Die Philippinen und ihre Bewohner; sechs Skizzen. Würzburg, Stuber'sche Buchhandlung (1869) 8°, 143 pp., 1 map; *see also* Zeitschr. f. wiss. zool. **13**: 563–569.

SEMPER, C. Reisen in Archipel der Philippinen. Zweiter Theil. Wissenschaftliche Resultäte. Leipzig, Engelmann (1868–1902) 5 vols.

SMITH, WARREN DUPRÉ. Orbitoides from the Binangonan limestone, etc.: Philip. Journ. Sci. **1** (1906) 203–209, 2 pls.

SMITH, W. D. The Bulacan iron deposits: Min. Resources P. I. for 1909 (1910) 32–33.

SMITH, W. D. Geology of the Philippine Islands: Min. Resources P. I. for 1909 (1910) 54–56. (Resumé.)

SMITH, W. D. The essential features of the geology of the Philippine Islands: Philip. Journ. Sci. § A **5** (1910) 307–342, 6 pls., 3 maps; *cf.* Eng. and Min. Journ. **92** (1911) 602; *ex* Min. and Sci. Press **103** (1911) 41 and 42, and Mining Journ. **93** (1911) 577 and 578.

The Philippine Islands, with a chapter on the lithology by J. P. Iddings: Handbuch der regionalen Geologie **6** (1910) 5, 24 pp., 1 map. *See* above reference.

SMITH, W. D. Contributions to the stratigraphy and fossil invertebrate fauna of the Philippine Islands: Philip. Journ. Sci. § A **8** (1913) 235–300, 20 pls.

SMITH, W. D. The geology of Luzon, P. I.: Journ. of Geol. **21** (1913) 29–61.

SMITH, W. D. Geologic and physiographic influences in the Philippines: Bull. Geol. Soc. Am. **28** (1917) 515–542, 2 pls. 1 map.

SMITH, W. D. Geol. and Min. Resources of the P. I. Bureau of Science publication No. 19 (1925).

SMITH, W. D., and P. R. FANNING. Iron in the Philippines: Min. Resources P. I. for 1910 (1911) 57–60.

SMITH, W. D., and M. GOODMAN. Geology and Mineral resources of the Philippine Islands: Far Eastern Review **4**[1] (1907) 4–8.

SPRINGER, J. F. Primitive iron smelting in the Philippine Islands: Iron Trade Review **58** (1916) 77–80.

STEERE, J. B. Volcanoes and earthquakes in the Philippines: Scientific American, New York (1898) 395.

STEINMANN, JOHANN. Handbuch der regionalen Geologie **6** (1910). *See* W. D. Smith.

VIGO, MENDEX DE. Historia geográfica, geológica y estadística de Filipinas. Manila (1876) 8°, 2 vols., maps.

YABE, H. Notes on a Lepidocyclina-limestone from Cebu; Science reports of the Tohoku Imperial University, 2d ser. (Geology) **5**[1] (1919) 37–51, 2 pls.

ILLUSTRATIONS

PLATE 12

FIG. 1. Well-stratified Binangonan limestone dipping downstream at Suclib cave.

2. The mouth of the underground river from locality 22 to locality 26 on Angat River, showing Binangonan limestone, caves, and terminals of underground passages.

PLATE 13

FIG. 1. Locality 44. Waterfalls on fault scarp across Osboy Creek (fault 3). The stream bed in the foreground is limestone. The escarpment is basalt.

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PLATE 16

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2. Novaliches dam of the Metropolitan Water District nearing completion.

PLATE 17

Interior of a cave at Montalban.

PLATE 18

FIG. 1. Basal Oligocene shales and sandstones at Montalban Gorge showing the steeply dipping beds.

2. Interior of a cave at Montalban.

PLATE 19

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PLATE 20

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PLATE 21

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2. Post Jurassic augitite, porphyritic with a glassy to hypocrystalline groundmass.

PLATE 22

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PLATE 23

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PLATE 24

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PLATE 25

FIG. 1. Binangonan limestone near the andesite contact at locality 53, on Katitinga Creek, showing fossils and fragments of plagioclase and hornblende.

2. Binangonan limestone.

PLATE 26

FIG. 1. Foraminifera in Binangonan limestone from locality 53, Katitinga Creek.

2. Characteristic lepidocyclina in Binangonan limestone from locality 53, on Katitinga Creek. This fossil is found in all the limestone outcrops although it is hard to distinguish.

PLATE 27

Lepidocyclina in Binangonan limestone from locality 53 on Katitinga Creek.

PLATE 28

Montalban Gap.

TEXT FIGURES

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2. Faulting at Novaliches River.

3. Map showing the extension of the western fault of Mariquina Valley (fault 7).

PLATE 1. THE METROPOLITAN WATER DISTRICT DAM AT MONTALBAN GORGE.

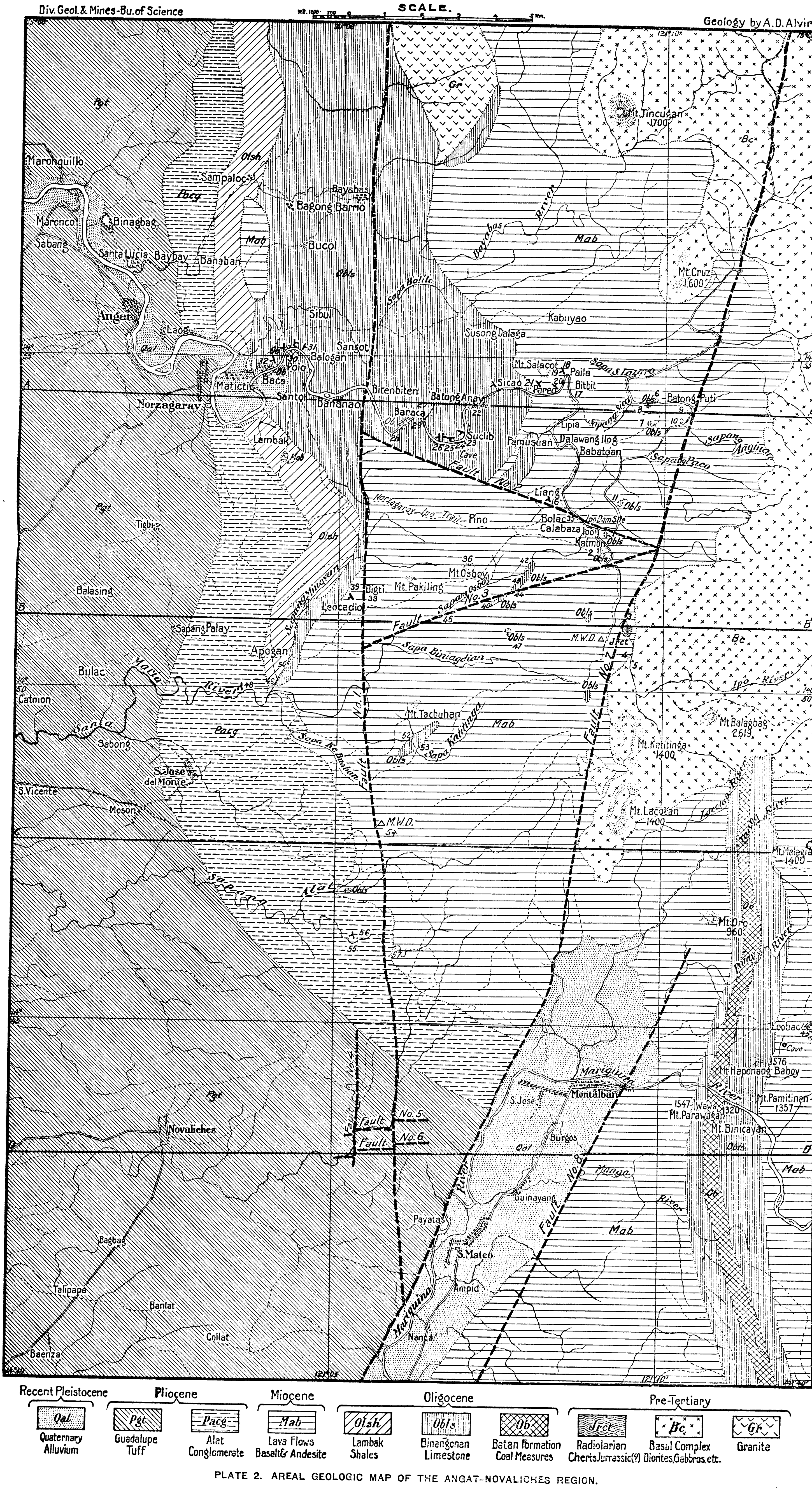

PLATE 2. AREAL GEOLOGIC MAP OF THE ANGAT-NOVALICHES REGION.

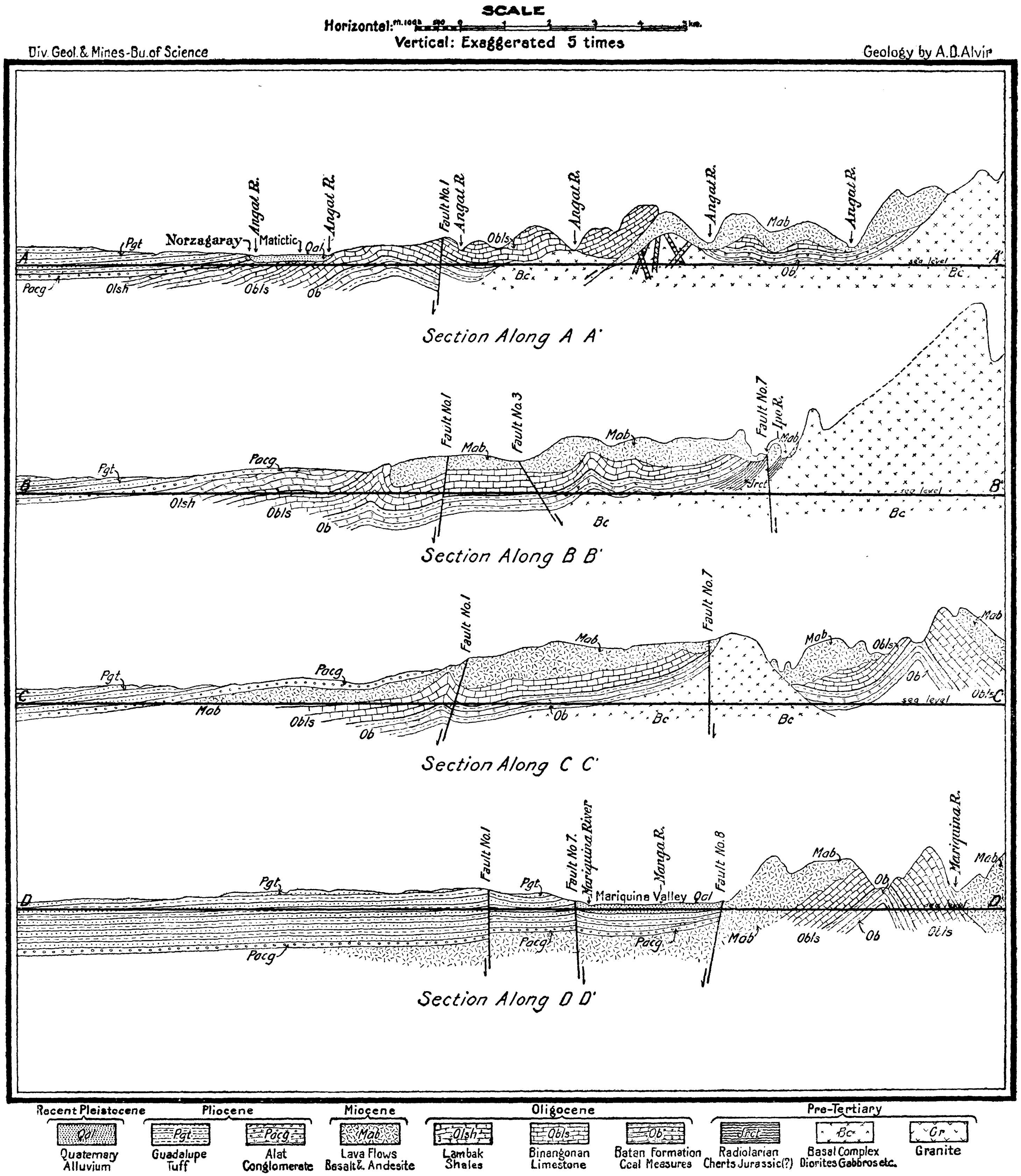

PLATE 3. GEOLOGIC CROSS SECTIONS OF THE ANGAT-NOVALICHES REGION.

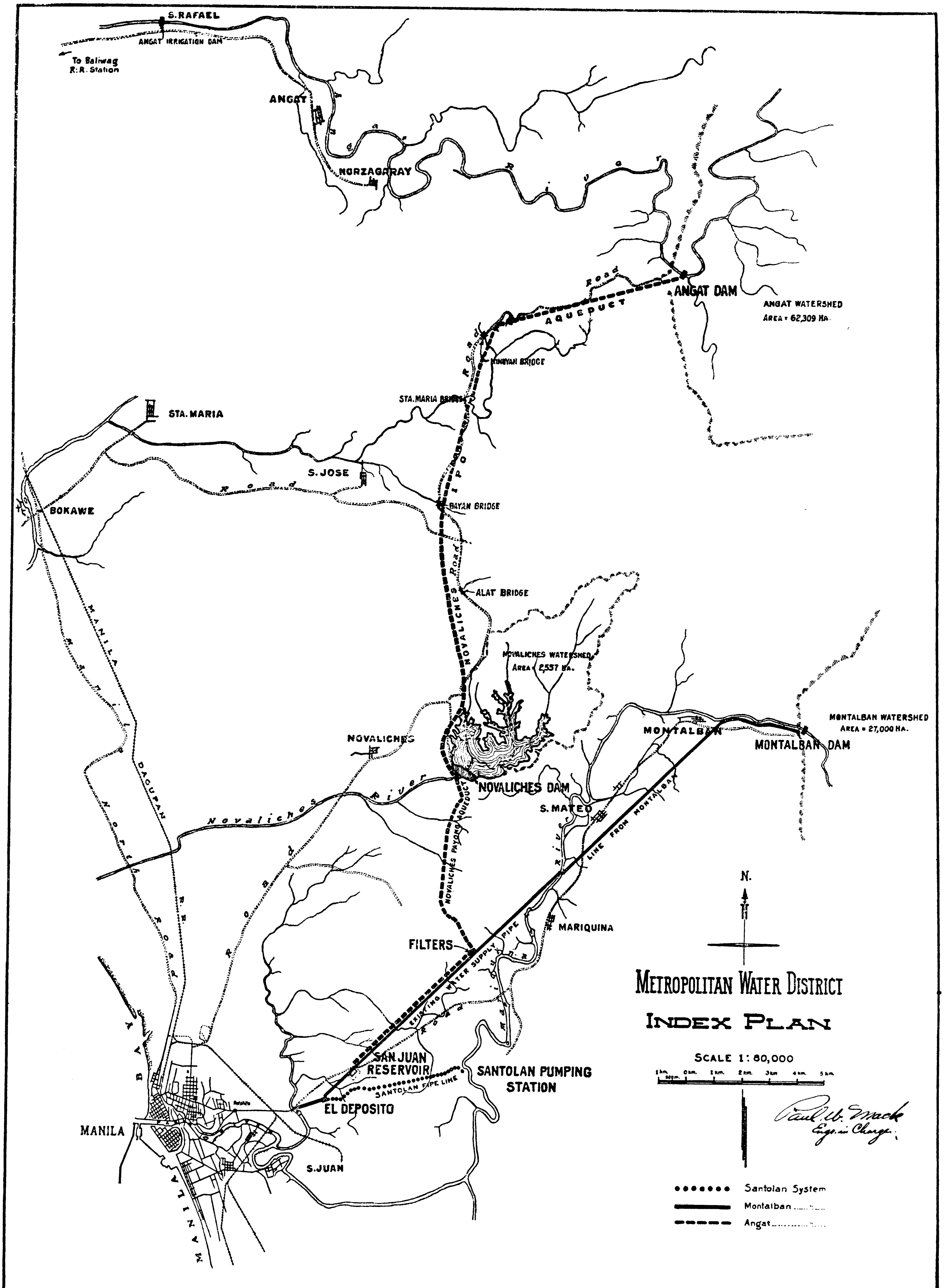

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PLATE 5. VIEW NORTHEAST FROM THE RAILROAD DEPOT AT MONTALBAN.

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PLATE 6.

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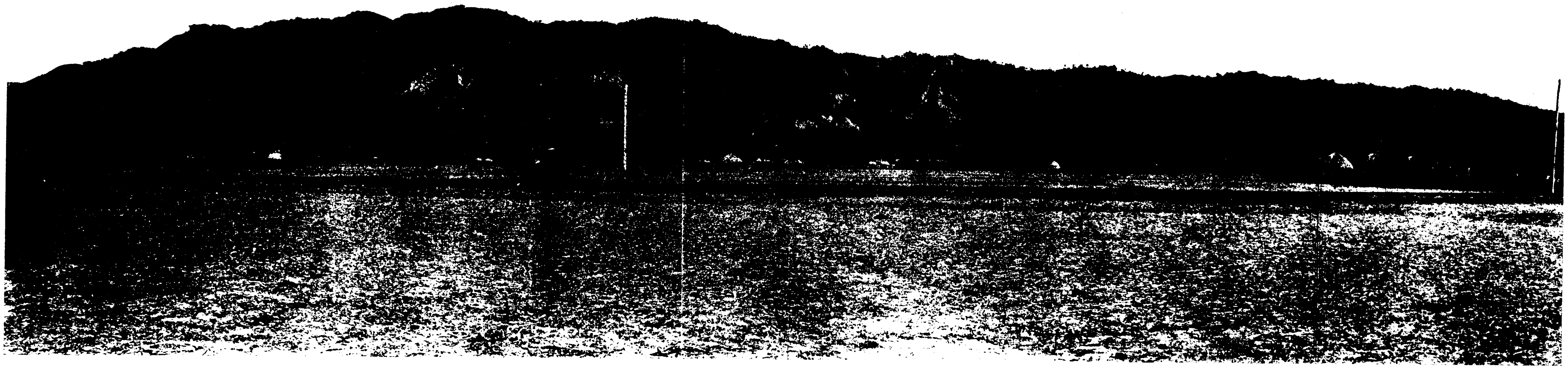
PLATE 7.



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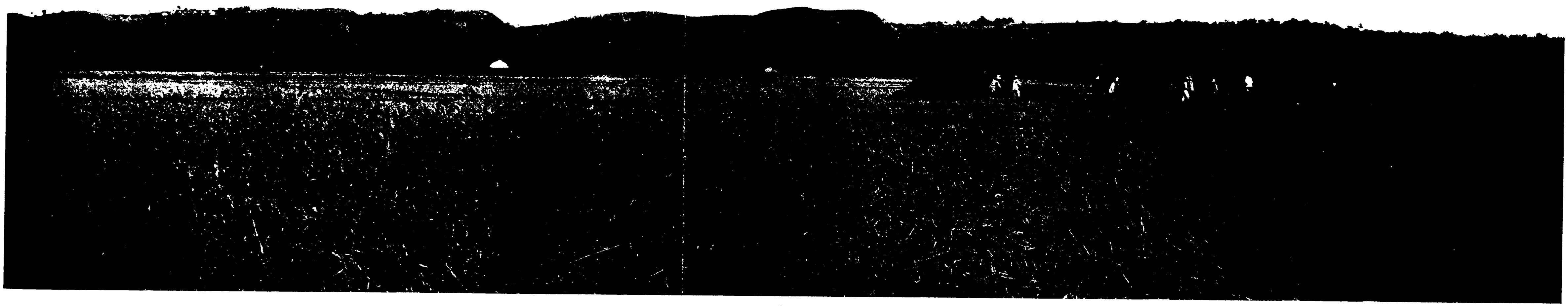

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PLATE 8. THE FAULT SCARPS OF MARIQUINA VALLEY.

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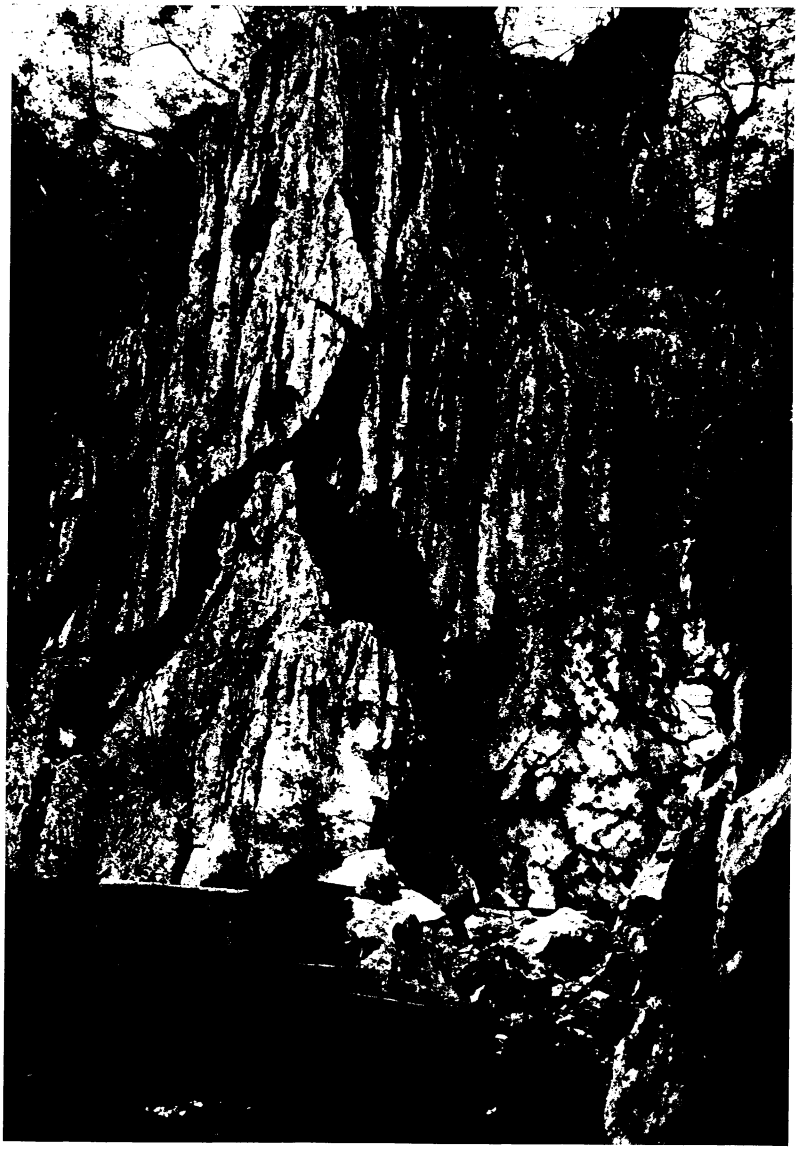
PLATE 9.



Binangonan limestone outcrop at Bicti, showing the broken character of the rock and the rain solution channels.

PLATE 10.

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PLATE 11.

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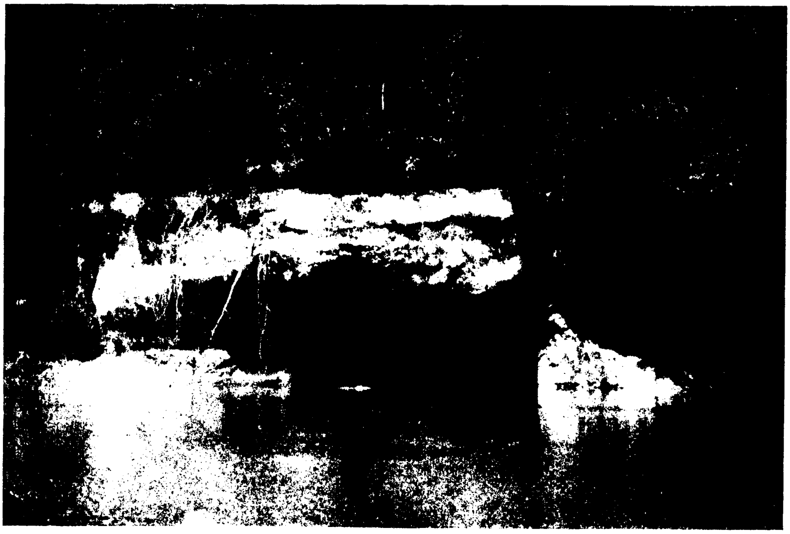

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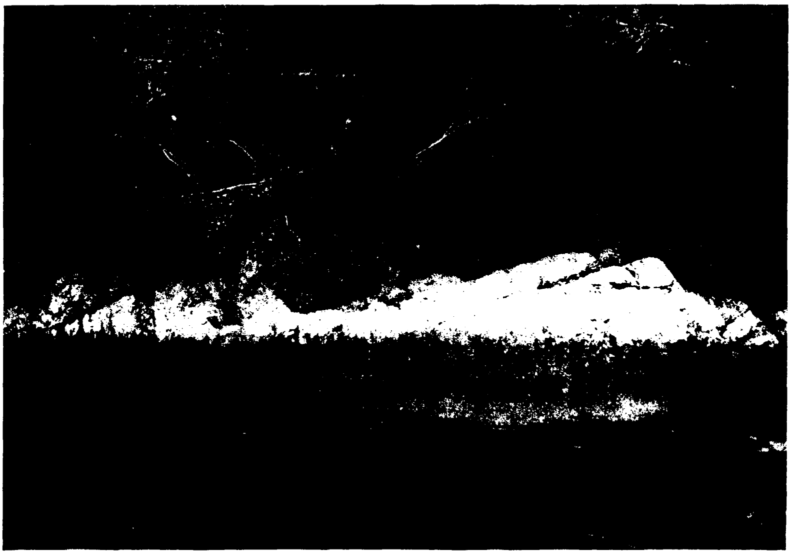

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PLATE 13.

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PLATE 14.

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PLATE 16.

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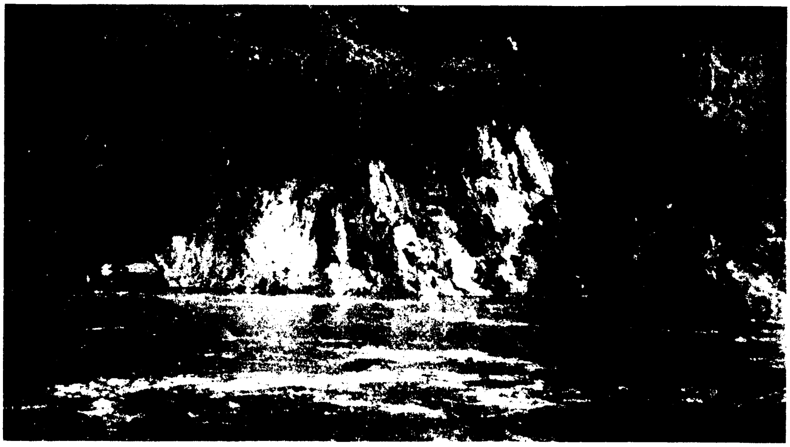

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PLATE 18.

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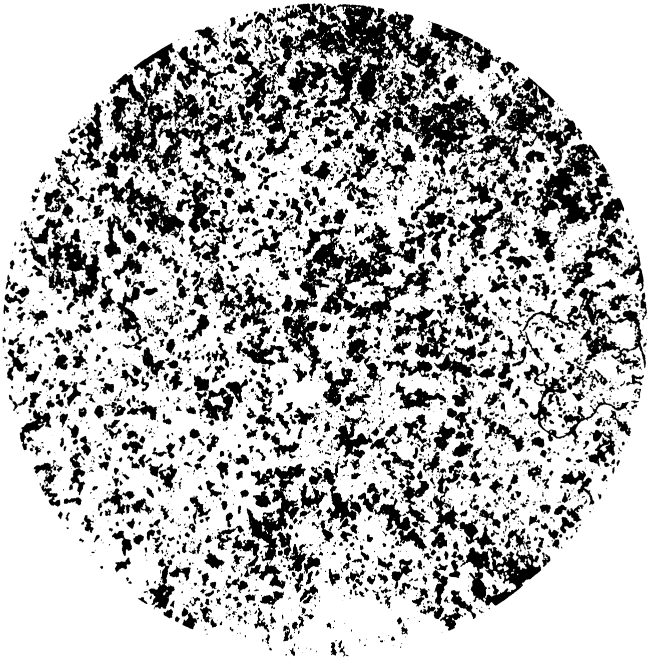
PLATE 19.



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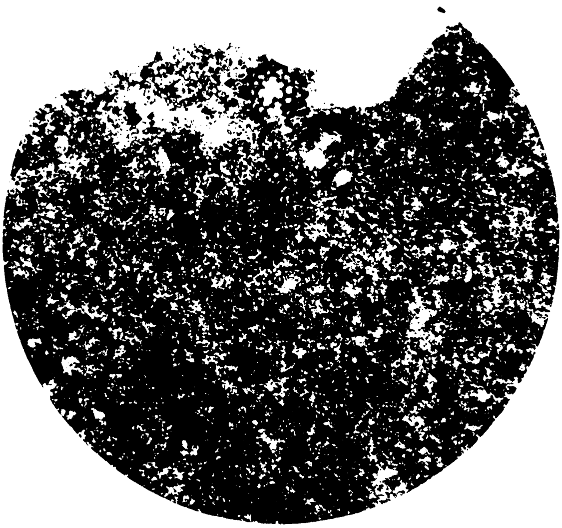

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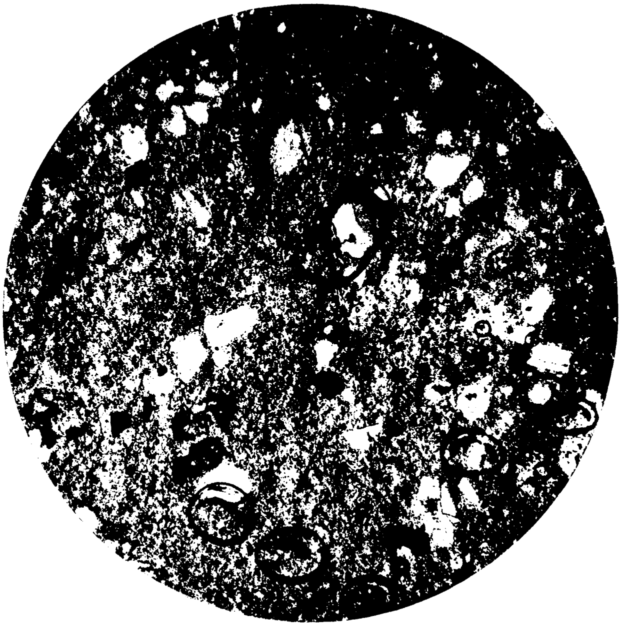

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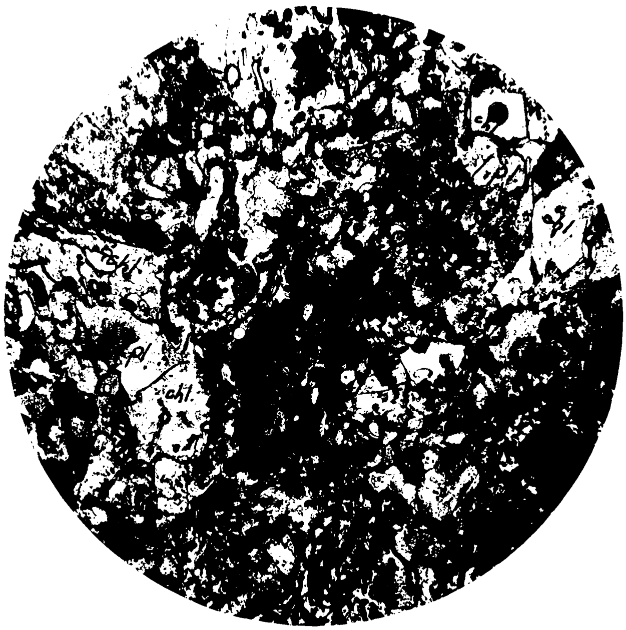

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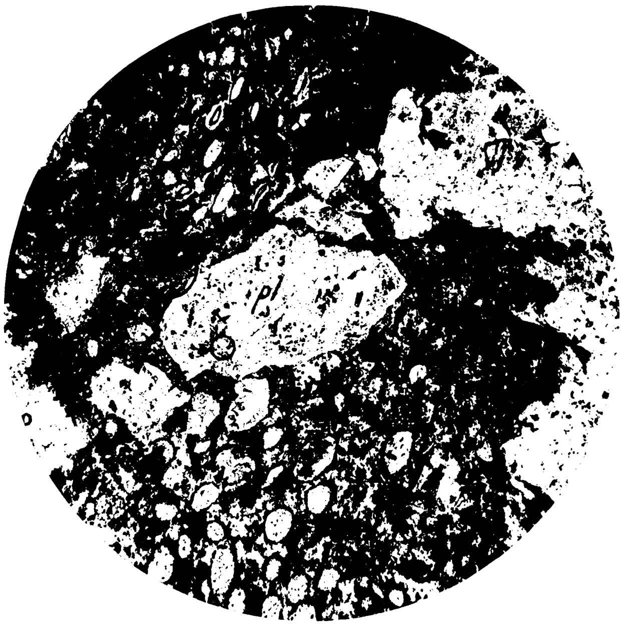

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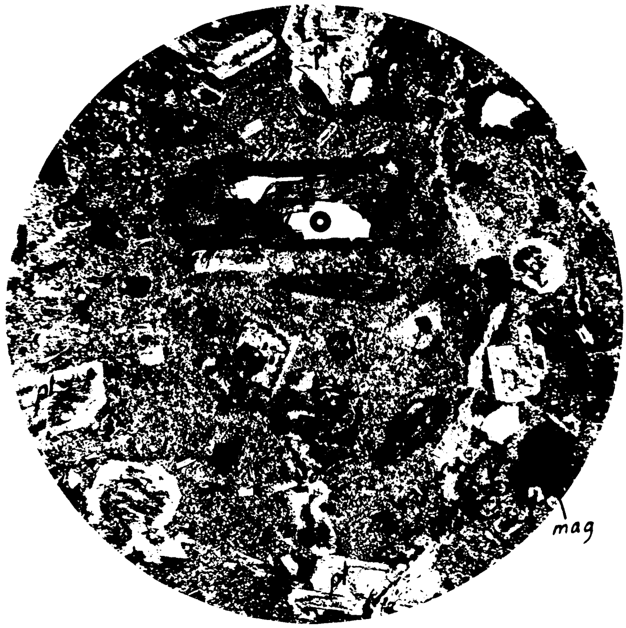
PLATE 23.



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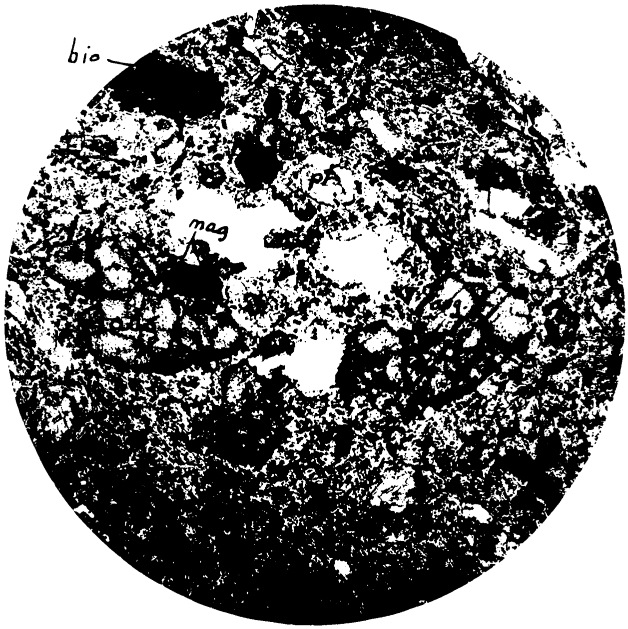

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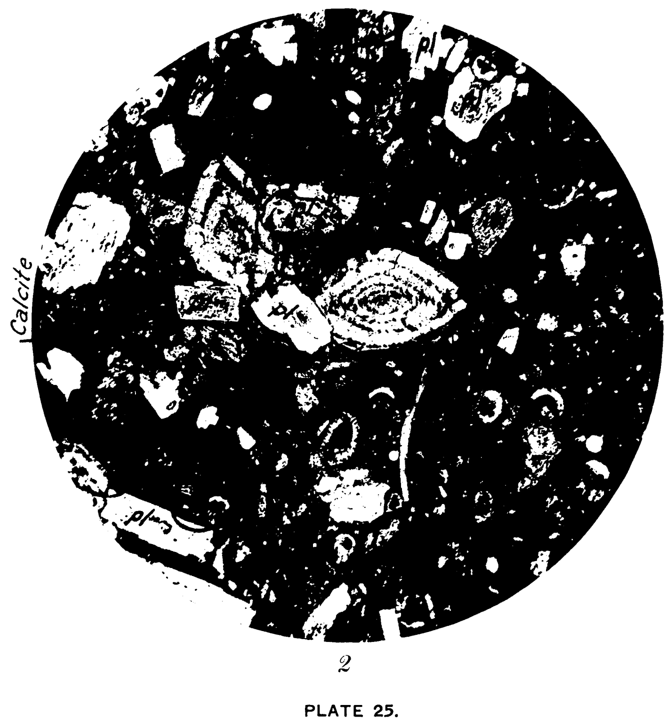

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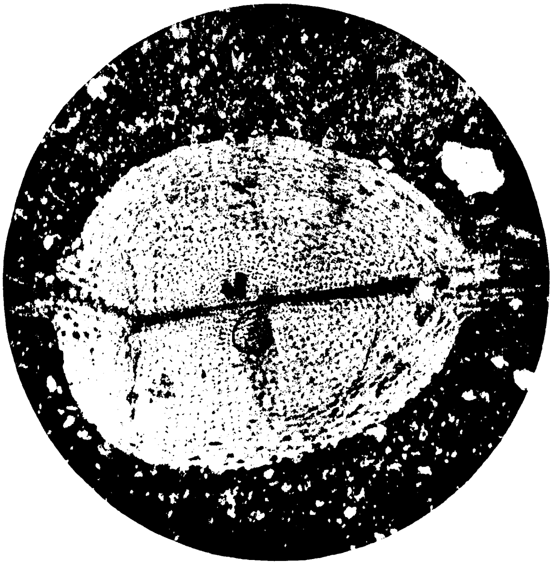

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PLATE 26.

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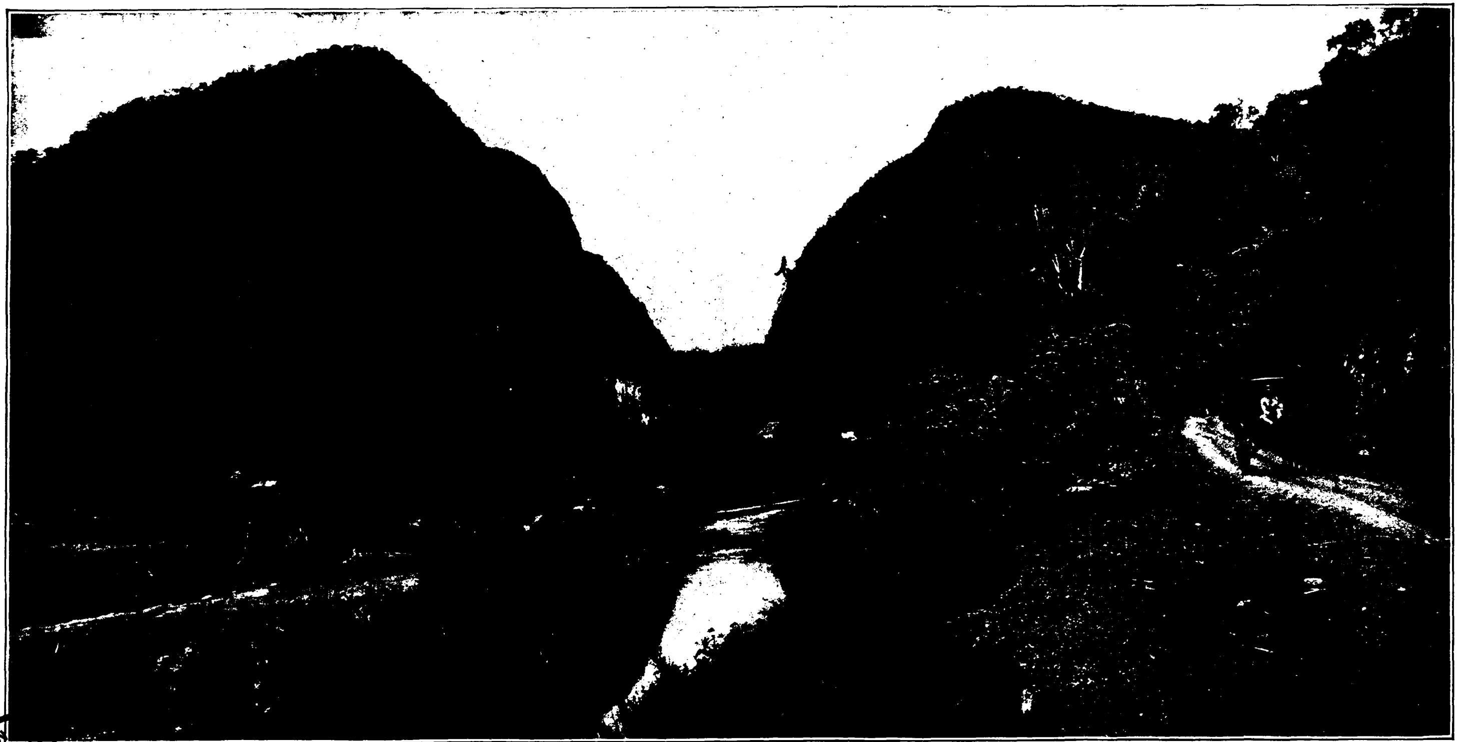
PLATE 27.



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VOL. 40, NO. 4 DECEMBER, 1929

THE PHILIPPINE JOURNAL OF SCIENCE

MANILA
BUREAU OF PRINTING
1929

Entered at the post office at Manila, P. I., as second-class matter.

THE PHILIPPINE JOURNAL OF SCIENCE

Published by the Bureau of Science, Department of Agriculture and Natural Resources
Government of the Philippine Islands

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 40 DECEMBER, 1929 No. 4

NOTES ON PHILIPPINE TERMITES, III

By S. F. LIGHT

Associate Professor of Zoölogy, University of California, Berkeley

NINE PLATES AND EIGHT TEXT FIGURES

Coptotermes vastator sp. nov., described below, is by far the most destructive termite species of the Philippines; it is responsible for at least 90 per cent of the damage done by these insects and for all cases of major damage. There are some six species of *Coptotermes* in my collection of Philippine termites, but *Coptotermes vastator* is the only species that is at all common. It is one of the commonest termite species in the Islands and forms with *Macrotermes gilvus* (Hagen), *Neotermes malatensis* Oshima, *Microcerotermes* spp., and *Nasutitermes* spp. the conspicuous and commonly encountered elements of a much more extensive termite fauna.

As the distribution and collection records given below will show, I have this species in my Philippine collections from the islands of Luzon, Marinduque, Mindoro, Tablas, Samar, Negros, Cebu, Mindanao, Basilan, and Palawan. The species is also represented in collections from Manila and the following provinces in Luzon: Rizal, Bataan, Cavite, Laguna, Batangas, Tayabas, Bulacan, Pampanga, Pangasinan, Mountain, Ilocos Norte, and Cagayan. The wide distribution elsewhere and the incompleteness or entire lack of termite collections from the provinces and islands not represented in this list lead to the belief that the absence of records of its presence there is merely an index to the incompleteness of the collections in those localities rather than to breaks in the continuity of distribution of the species over the Archipelago.

A study of the collections according to the newer method (Light, 1927), which involves measurements of a large range of material and determination of proportional characters and ranges of variation, is under way. It seems necessary to avoid delay in naming so important a Philippine species, and hence this manuscript description of several years standing is published now preliminary to a more complete definition of the species.

COPTOTERMES VASTATOR sp. nov. Plates 1 to 6; text figs. 1 to 4.

Coptotermes travians OSHIMA, Annot. Zoöl. Jap. 8 (1914) 555; Philip. Journ. Sci. § D 12 (1917) 223; 17 (1920) 491.

Coptotermes formosanus OSHIMA, Philip. Journ. Sci. 17 (1920) 491.

DIAGNOSES

Adult.—Small, not over 12 millimeters long with the wings, head about 1.35 millimeters wide with the eyes, and 1.48 millimeters long to the tip of the labrum; head and abdominal terga dark brown, wings very light with only a faint brownish tinge, without costal stripe and with very little pigmentation at base of wing membranes; hairs of the wing membrane small, light, and evenly spaced except on either side of the medial and cubital veins and their branches where a clear space borders the single line of hairs marking the course of the veins; characteristically distinct, white, crescentic "antennal spots" at right angles to the long axis of the head and with the concave margin turned toward the clypeus; fontanel extremely minute, at the end of a tiny uplifted and projecting tube.

Soldier.—Head without mandibles about 1.4 millimeters long and 1.05 to 1.12 wide, not greatly flattened; fontanel about 0.15 millimeter in diameter, tubular but not greatly extended, making an angle of about 30° with the vertical; pronotum about 0.46 millimeter long and 0.8 millimeter wide; gula strongly contracted with a maximum width of about 0.35 to 0.40 millimeter and a maximum width of 0.23 millimeter; a single row of large spinelike hairs on each dorsal abdominal sclerite.

DESCRIPTIONS

Adult.—Plates 1 to 5, text figs. 1 and 2. Vertex and frons very dark brown, in some cases nearly black; postclypeus and labrum yellow, anteclypeus white, occiput, pronotum, and posterior region of mesonotum brown; pronotum lightest in the middle, anterior and posterior regions darker; posterior region of the metanotum lighter than the corresponding portion of the mesonotum; anterior regions of the mesonotum and metanotum

very light yellow; abdominal terga brown with an olive or smoky tinge; antennæ, palpi, legs, and underside of the head and body light yellowish brown; wings transparent with a faint brownish tinge, costal margins opaque, somewhat darker; margins and portions of the surface of the wing scales dark smoky brown.

Head not strongly pilose, with scattered, more or less symmetrically distributed spiny hairs and more numerous smaller hairs; pronotum and wing scales (dorsal surface) with numer-

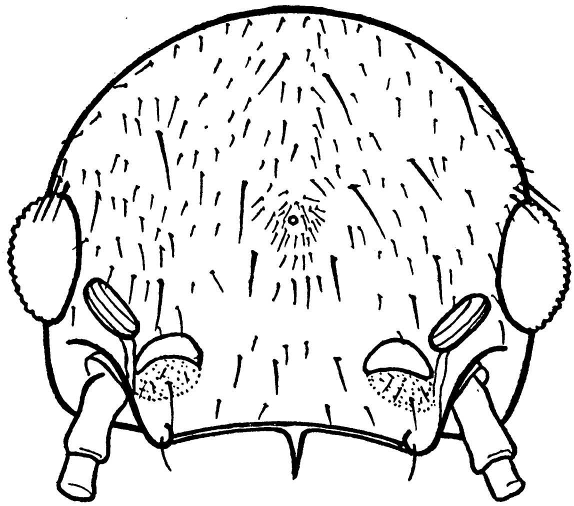


FIG. 1. *Coptotermes vastator* sp. nov., alate, head capsule in dorsal view, ca. × 60.

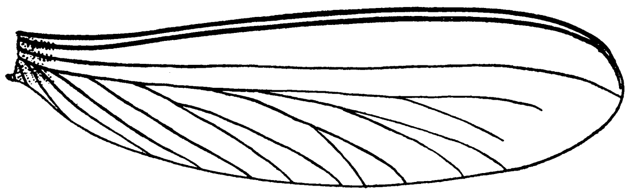


FIG. 2. *Coptotermes vastator* sp. nov., alate, sketch of forewing.

ous long spiny hairs; abdominal terga and sterna with a close-set growth of recumbent hairs and a more or less regular posterior row of erect hairs; pleural membranes of the abdomen of the female set with a thick coat of long rather slender hairs more or less clumped in certain areas, the same regions of the male nearly naked; wing membranes rather thickly and evenly set on both surfaces with short white hairs (Plate 2, figs. 4 and 5) about 0.58 millimeter long, separated from each other by a little more than the length of the hairs, distal half of posterior

margin of both wings with a close-set band of these hairs; costal margins and radial sector set with larger, darker hairs.

Head broad oval, sides slightly converging in front of eye, posterior to eye rounding broadly into the convex posterior margin, the whole margin behind the eye making a curve considerably flatter than a semicircle; surface of the head elevated between the eyes, particularly so in an arcuate ridge between the ocelli, convex posteriorly and again at the anterior margin of the frons; behind the elevated region increasingly depressed toward the posterior margin where the head is very low.

Sutures of head invisible except longitudinal portion of epicranial suture which is very fine and can be made out with difficulty; a median depressed area, just behind the ridge joining the ocelli, is marked by a median light area; fontanel extremely tiny (Plate 5, fig. 2) with dark rim, located at end of a tiny, uplifted, projecting tube about twice as long as diameter of fontanel, located in a longitudinal groove in the elevated ridge above referred to and marked by a small light spot and an aggregation of small hairs which lie just below and in front of fontanel.

"Antennal spots" distinct (Text fig. 1; Plate 2, fig. 1), white, thickly crescentic, at right angles to the long axis of head and separated from the anterior end of the ocellus on either side by less than their short diameters, concave margin of crescent turned toward the postclypeus; width of crescent from horn to horn about 0.15 millimeter, somewhat less than length of ocellus (0.177 millimeter); greatest (median) length of crescent 0.08 millimeter, slightly more than the width of the ocellus (0.075 millimeter).

Labrum tongue-shaped, slightly broader than long (0.43 millimeter long by 0.47 millimeter wide), with a broad but very short hyaline apical portion; swollen but slightly at center; posterior margin somewhat convex, anterolateral corners rounding broadly into the rounded anterior border.

Anteclypeus about as broad as long, longer than postclypeus, narrowed near the labrum which it somewhat overlaps.

Postclypeus trapezoidal, somewhat swollen, distinctly but not completely divided in the midline by a pigmented projection of the center of the frons, posterior margin convex, anterior margin concave; each half longest in its medial two-thirds and

decreasing in length to its very narrow lateral margin; length 0.14 millimeter, width 0.57 millimeter.

Mandibles as in Plate 4.

Gula considerably longer than wide with nearly straight anterior and posterior margins; lateral margins convex, converging strongly in anterior one-third, posterolateral corners rounded; length 0.58 millimeter, width 0.475 millimeter.

Eyes medium sized (that is, diameter between one-quarter and one-third the width of head without eyes); not strongly projecting.

Ocelli low, hyaline, elongated, oval, more than twice as long as wide; directed anteriorly and medially making an angle of 45° with the long axis of the head; posterior and outer end approaching very near the eye in its anterior one-third (Plate 2, fig. 1); length 0.177 millimeters, width 0.075.

Antennæ of 20 to 22 segments (Plate 1; Plate 2, fig. 1), nearly twice as long as head (2.5 millimeters long where 21 segments); segment I largest, cylindrical, not quite twice as long as wide (0.2 millimeter long by 0.106 millimeter wide), slightly narrowed at center; II cylindrical, about as long as wide (0.84 millimeter); III usually smallest, often disk-shaped but varying in length; IV as long as III (22 segments) or longer; IV to VIII wider than long, increasing in length, IX approximately spherical; IX to XX or XXI increasingly long and clavate; terminal segment as long as preceding but narrowest, ovate.

Pronotum (Plate 2, fig. 3) slightly narrower than head with eyes; 1.2 millimeters wide and 0.84 long; with weakly concave anterior border, with or without very slight indications of a median notch; anterolateral corners rounded, lateral margins receding strongly and rounding into the biconvex posterior margin; median line faint, T-shaped area faint or invisible, a light spot near each anterolateral corner.

Forewing with scale 10.2 millimeters long, hindwing 9.5 to 10 millimeters long, maximum wing width 2.5 millimeters, costal margin and "radial sector" greatly thickened and conspicuous, other veins inconspicuous (Plate 3); radial sector, median, and cubitus about equally spaced at point of entry into forewing membrane (Plate 2, fig. 4); radial sector curves forward until near the costal margin and runs parallel to it and unbranched until it merges with it near the tip of the wing; the median,

curving somewhat posteriorly, runs near and parallel to the cubitus, separated by a wide space from the radial sector to which it is often united by one or two faint rudimentary branches, distally it is divided, width from two to four branches, the point of origin of the first branch varying widely from near the middle to near the tip of the wing; median of hindwing arises from radial sector near the base of wing membrane (Plate 2, fig. 5); veins of both wing membranes (median and cubitus and branches) scarcely visible, their course marked, however, by a single line of hairs separated by a distinct space from the surrounding hairs of the wing membrane; cubitus with from seven to nine main branches to the wing margin, from one to three of which are again divided, the number of main and secondary branches being in inverse ratio to the amount of division of the media; bases of media, cubitus, and the first two branches of the cubitus are thickened and pigmented and marked (as is a very narrow strip of the basal portion of the wing membrane) by tiny papillæ (Plate 2, fig. 5) suggesting those characterizing the wing ornamentation in the Kalotermitidæ; anal furrow white, very distinct in forewing (Plate 2, fig. 4), where it is slightly convex and runs into the posterior margin of the scale not far beyond its center, less distinct in the hindwing, where it is straight and ends at the suture; anal margin of scale with a small but distinct convexity proximal to the posterior end of the furrow (Plate 3); no "costal stripe" (Plate 2, fig. 5) below the radial sector such as characterizes many other species of this and other widely separated genera.

Cerci similar in male and female, with a thick basal joint and slender, elongated, incompletely segmented distal portion.

Sexual dimorphism.—Abdomen of male longer and slenderer than that of female; fifth sternite of female with slightly concave posterior border, sixth sternite of female terminal, greatly enlarged, much longer than other sternites but wider than long; posterior margin strongly convex but with a faint median notch; fourth sternite of male longest, fifth to eighth decreasing in size and proportionate length, fifth with straight or convex posterior margin, sixth with concave posterior margin.

Styles absent in female, in male arising from narrow white area at center of posterior margin of eighth abdominal sternum, slender, yellow, separated from one another by space nearly equal to their length.

Pleural membranes of abdomen of female closely set with a recumbent coat of long yellow hairs evidently connected with

trophallactic function, same membranes of male practically naked.

Measurements of alate of Coptotermes vastator sp. nov.

	mm.
Length, with wings	11.0–12.0
Length, with wings	6.0–7.0
Forewing, length	16.2
Forewing, width	2.5
Hindwing, length	10.0
Head, width with eyes	1.35
Head, width without eyes	1.18–1.22
Head, length	1.48
Head, length to clypeus	0.95–1.01
Pronotum, length	0.85
Pronotum, width	1.13–1.2
Antennæ, length	2.47
Segment I of antennæ, length	0.2
Segment I of antennæ, width	0.115
Segment II of antennæ, length and width	0.085
Hairs of wing membrane, length	0.055
Ocellus, length	0.17
Ocellus, width	0.075
Crescentic antennal spot, length from horn to horn	0.15
Crescentic antennal spot, maximum diameter	0.08
Labrum, length	0.43
Labrum, breadth	0.47
Postclypeus, maximum length	0.14
Postclypeus, maximum width	0.57
Gula, length	0.57
Gula, maximum width	0.475
Fontanel, diameter of aperture	0.01

Soldier.—Plate 6; text figs. 3 and 4. Head light yellow to yellow, mandibles red to reddish black, pronotum, antennæ, and hairs very pale yellow; other parts white to whitish yellow.

Head hairs very few and widely scattered, usually a girdle of six to eight large hairs around the head in front of its center; antennæ and palpi weakly haired (compared with other termites); labrum with two long, curved, slender hairs near tip; pronotum sparsely haired, a row of long, upright, widely spaced hairs around the margin, the two nearest the center of the anterior margin especially large; much smaller pronotum hairs scattered, most numerous on either side of the midline in the anterior portion; body not strongly haired; terga and sterna with smaller more or less recumbent hairs and a single row of longer, upright hairs near the posterior margin; distal half of tibiæ rather thickly set with short, distally-directed, spiny

hairs; tibial spines slightly bent, two on middle and hind tibiæ and three on foretibiæ.

Head elongated, ovate, varying considerably in shape and size among the soldiers of a given colony, between the soldiers of different colonies of a given region, and between races in different islands; sides parallel or faintly convex in the middle, converging strongly anteriorly from a point as far behind the antennæ as the mandibular articulation is in front of them; posterolateral corners rounding into the flatly convex posterior margin which is marked by a median slightly projecting region. Seen in profile (side view) the lower margin curves distinctly (text fig. 4) from the edge of the projecting region mentioned above to a maximum median ventral convexity near the middle of the head (measured from occiput to fontanel), then curves upward, but less strongly, to the mandibular articulation; the dorsal profile slopes gently upward from the very low occipital end for about one-third of its length, is flat in the median one-third with a faint median concavity, and slopes down in the anterior one-third to the upper rim of the fontanel; sides rounded; dorsal surface sloping toward the sides, particularly so from a point somewhat behind the antennæ where the head is drawn out to form the fontanel tube characteristic of the genus.

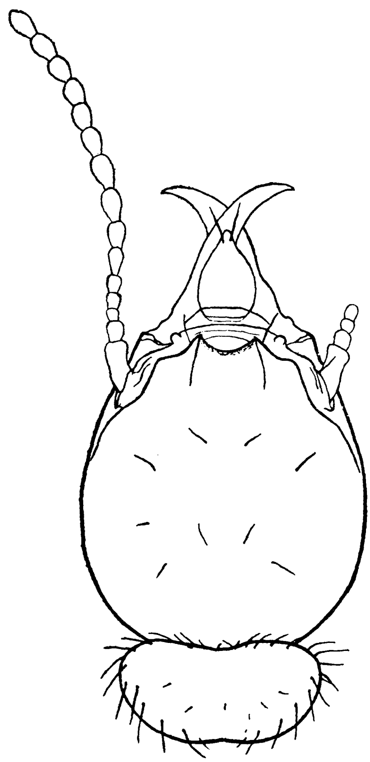


FIG. 3. *Coptotermes vastator* sp. nov., head of soldier from type colony, dorsal view.

Labrum tongue-shaped (Plate 6, fig. 3), reaching beyond the middle of the mandibles; sides convex in proximal one-half, converging very strongly in distal one-half where slightly concave; ending in a short, triangular, hyaline tip with two long,

slender, slightly curved hairs at its base; posterior margin somewhat convex, overlapping the clypeus above; posterior strip of labrum and anterior strip of clypeus (anteclypeus) hyaline; labral articulation on either side marked by distinct chitinous thickenings with incurved median ends; in median one-fifth no sign of separation between labrum and clypeus; labrum ornamented with what appear to be hairs with sunken bases (sensory hairs), which are particularly numerous in the distal region.

Clypeus trapezoidal, not clearly divided into anteclypeus and postclypeus; separation between frons and clypeus marked by a ridge forming the ventral rim of the fontanel aperture, marked at either end very near to the inner mandibular condyle by a single, long, spiny hair.

No eye rudiment visible even in cleared and dissected specimens.

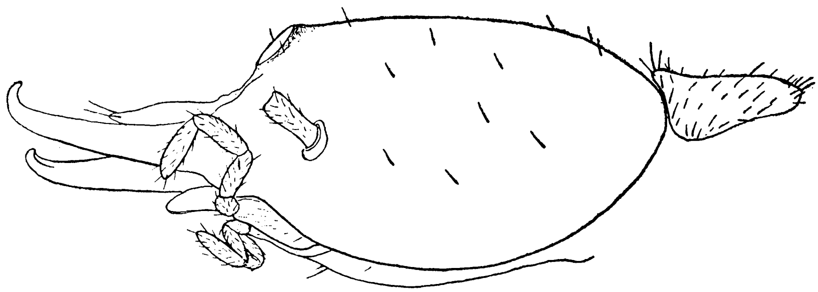


FIG. 4. *Coptotermes vastator* sp. nov., head of soldier, side view.

Antennæ about 1.5 millimeters long, with thirteen to sixteen, but usually fourteen or fifteen segments (Plate 6, figs. 1 and 3); I and II much as in adult; I cylindrical, about twice as long as broad (0.17 millimeter by 0.846 millimeter), somewhat swollen at the ends; II shorter and narrower (0.07 millimeter by 0.06 millimeter); III shortest and narrowest, obconic; where fourteen segments, IV about as long as III; where fifteen segments, III considerably shorter than IV, IV somewhat longer than broad, subspherical; V to VII increasing in length; VII to X about equal in length but increasingly clavate; XI to XIV decreasing in length; terminal segment about as long as next to last but narrower, ovate.

Mandibles (Plate 6) nearly straight in proximal two-thirds, bent inward increasingly toward the tips, which lie nearly at

right angles to the long axis; left mandible (Plate 6, fig. 2) slightly bent below the middle, making the outer margin of the basal half weakly convex; inner margin of left mandible smooth in distal half, basal half with a cutting edge bearing four crenulations increasing in size toward the base; internal surface of base of left mandible set off from above cutting plate by a notch and bearing a conspicuous chitinous plate, somewhat flattened above and directed distally and somewhat mediad, its tip reaching to the proximal margin of the basal crenulation; right mandible with smooth inner edge except near the base where it is somewhat roughened and marked, in some cases, by a low crenulation beyond which the blade slopes sharply to the much broader but untoothed mandible base; tips very sharply pointed; bases of mandibles with numerous tiny refractive spots connected with slender internal tubes (sunken hairs of a sensory nature).

Palpi long, maxillary palpi nearly as long as the mandibles (Plate 6, fig. 1).

Fontanel at end of an anterodorsal prolongation of the head surface; aperture circular, making more than a right angle with the mandibles; that is, tipped back at an angle of about 30° with the vertical, so as to make the aperture visible when the head is viewed from above; lower rim margin coincident with the ridge separating clypeus and frons, dorsal rim a thin projecting semicircular band of dark, externally wrinkled chitin; length of dorsal rim 0.02 millimeter; diameter of fontanel 0.15 millimeter.

Gula considerably narrowed behind, somewhat variable in proportions; 0.74 millimeter long from the anterior margin of occipital foramen to base of labium; maximum width 0.35, minimum width 0.22.

Pronotum with weakly biconvex anterior and posterior margins, anterolateral corners very broadly rounded to the middle of the lateral margins which recede rapidly from that point into the narrow posterior margin; anterior margin incompletely (dorsally) notched in the midline.

Cerci large, with a distal fingerlike portion about 0.1 millimeter long.

Styles lamp-chimney-shaped with plump basal portions contracted at point of origin and slender distal portions; about 0.09 millimeter long.

Measurements of soldier of Coptotermes vastator sp. nov.

	mm.
Length	5.0–6.0
Length without head	3.5–4.0
Head, length without mandibles	1.38–1.4
Head, length to fontanel	1.2
Head, width	1.045–1.13
Pronotum, length	0.46
Pronotum, width	0.8
Antenna, length	1.5
Segment I of antennæ, length	0.17
Segment I of antennæ, width	0.084
Segment II of antennæ, length	0.07
Segment II of antennæ, width	0.06
Labrum, length	0.388
Labrum, maximum width	0.30
Labrum, width at base	0.23
Hyaline tip of labrum, length	0.05
Hyaline tip of labrum, width at base	0.075
Hairs at tip of labrum, length	0.15
Mandible, left, length	0.82
Mandible, right, length	0.76
Gula, length (from anterior margin of cervical foramen)	0.74
Gula, maximum width	0.35
Gula, minimum width	0.23
Fontanel, diameter	0.15

Worker.—Small, inconspicuous, whitish or with a pale yellowish tinge; in life the abdomen often shows a pinkish or salmon tinge due to the intestinal contents seen through the transparent body wall.

Head, body, and appendages covered with a fairly close coat of small white or faintly yellowish hairs with a few longer more conspicuous hairs in a single row near the posterior margin of each sternum and tergum.

Sides of head in anterior half parallel or faintly convex, curving from about middle into curved posterior margin and making with it a semicircle; anterolateral corners nearly square; mandibular articulations considerably mediad leaving a nearly straight anterior surface on either side; head low, depressed in region of frons, clypeus swollen; sides of head rounded. Fontanel inconspicuous. No eye rudiments.

Labrum pentagonal, about as long as broad, swollen but little, with a short, broad, hyaline apical strip; surface ornamented with corrugations and rows of spots.

Antenna of fifteen segments, nearly as long as in soldier.

Pronotum shaped much as in soldier but with more strongly biconvex anterior margin.

Measurements of worker of Coptotermes vastator sp. nov.

	mm.
Length	4–5
Head, width	1.12
Head, length	1.33
Head, length to mandibular articulation	1.013
Antenna, length	1.48
Pronotum, length	0.38
Pronotum, width	0.68

Systematic position.—The species of *Coptotermes* in general and those of the Oriental Region in particular fall into distinct groups on the basis of the size and shape of the head of the

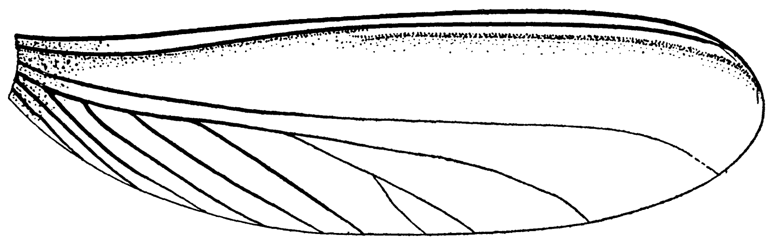


FIG. 5. *Coptotermes formosanus* Shiraki, from Honolulu, forewing. Note that it is larger than the forewing of *C. vastator* (see fig. 2 drawn to the same scale) and has more pigment at the base and in the form of a "costal stripe."

soldier. The two most definite groups I shall designate as the *travians* group and the *curvignathus* group. The former includes the forms in which the head is considerably elongated, is produced to form a fontanel tube, and is high in front, and in which the fontanel has an angle of inclination of less than 45°. Here fall the greater number of the Oriental species including *C. vastator* sp. nov. The species of the *curvignathus* group have soldiers with broad flat heads and large fontanels with a great angle of inclination.

The *travians* group itself falls into three more or less artificial groups of species based on the size of the head of the soldier. One consists of several very small undescribed Philippine species whose head width is less than 1 millimeter. A second, and intermediate group, consists of species with a head width in the soldier of from 1 millimeter to 1.25 millimeters and includes *C. bornensis*, *C. ceylonicus*, *C. formosanus*, *C. gestroi*, *C. heimi*,

Complete collection records of Coptotermes vastator sp. nov.

Collection.	No.	Collector.	First reported.	Island.	Province.	Locality.	Remarks.
Taihoku		R. C. McGregor	Oshima, 1920	Luzon		Manila	*C. formosanus* of Oshima.
Do		do	do	Panay	Antique	Culasi	*C. travians* of Oshima.
Author's	1	Light	This paper	Luzon		Manila	
Do	2	do	do	do		do	
Do	11	Miss Florentina Hernandez	do	do		do	
Do	13	do	do	do		do	
Do	29	Miss Ursula B. Uichanco	do	do		do	Attacking Philippine Normal School building.
Do	35	McGregor and Light	do	do	Rizal		
Do	54	Miss Hernandez	do	do		Manila	
Do	55	McGregor	do	do		do	Alates in nest, June 13.
Do	56	W. A. Wiedemann	do	do		do	Attacking books in Escolta store.
Do	64	McGregor and Light	do	do	Rizal		
Do	70	Miss Hernandez	do	do		Manila	
Do	76	Light	do	do		do	
Do	86	McGregor and Light	do	do	Rizal		
Do	87	Light	do	do		Manila	Attacking San Andres School building.
Do	88	do	do	do		do	Attacking storeroom supplies of University of the Philippines Hall.
Do	92	McGregor and Light	do	do	Bulacan		
Do	93	do	do	do		Manila	
Do	125	do	do	do		do	Attacking telephone poles.
Do	126	do	do	do		do	Do.
Do	129	Miss Uichanco	do	do			
Do	130	do	do	do		do	Attacking Philippine Normal School building.
Do	131	do	do	do		do	Do.

Complete collection records of Coptotermes vastator sp. nov.—Continued.

Collection.	No.	Collector.	First reported.	Island.	Province.	Locality.	Remarks.
Author's	133	Miss Uichanco	This paper	Luzon		Manila	Attacking Philippine Normal School building
Do	145	Miss Hernandez	do	do		do	Do.
Do	171	Prof. L. D. Wharton	do	Cebu	Cebu	Cebu	Attacking Smith-Bell bodega.
Do	195	McGregor	do	Luzon	Rizal	Pasay	
Do	200	Miss Hernandez	do	do		Manila	
Do	213	Light	do	do		do	Attacking Freer Chemical Laboratory building. Came in over gas pipe.
Do	244	McGregor and Light	do	do	Rizal	Balintauac	
Do	247	E. Lucas	do	do	do	Pasig	
Do	259	G. Gonzales	do	do	Tarlac	Concepcion	
Do	265	do	do	do	do	do	Workers show fungus disease!
Do	275	Mr. Lopez	do	do			Queen present.
Do	276	Miss Paz Teopaco	do	do	Pampanga	San Fernando	
Do	325	Dr. J. Andaya	do	do		Manila	Attacking wood work of Student Y. M. C. A. building.
Do	334	McGregor and Light	do	do	Batangas	Tanauan	
Do	336	do	do	do	do	Batangas	
Do	355	do	do	do	Cavite		
Do	358	do	do	do	Laguna	Santo Tomas	
Do	405	Daniel Riola	do	do	Tayabas	Tayabas	
Do	406	do	do	do	do	do	
Do	415	McGregor and Light	do	do	Rizal	Balintauac	
Do	420	do	do	do	Laguna	Los Baños	
Do	429	Light	do	do		Manila	
Do	430	do	do	do		do	

Do.	438	McGregor	do.	do.		do.	
Do.	449	do.	do.	do.		do.	
Do.	454	Light	do.	do.		do.	
Do.	457	do.	do.	do.		do.	
Do.	458	do.	do.	do.		do.	
Do.	461	do.	do.	do.	Rizal	Pasay	Alates in nest, May 5.
Do.	465	do.	do.	do.		Manila	Adults flying, evening of May 3, 1921.
Do.	467	McGregor and Light	do.	do.	Rizal	Balintauac	
Do.	471	Dr. Hilario Roxas	do.	do.		Manila	Alates flying, evening of May 10, 1921.
Do.	472	Light	do.	do.	Rizal	Pasay	
Do.	473	do.	do.	do.	do.	do.	
Do.	479	do.	do.	do.	Pangasinan	Rosales	
Do.	486	Mr. Tansinsin	do.	do.	Bulacan	Bulacan	
Do.	487	do.	do.	do.	do.	do.	
Do.	488	do.	do.	do.	do.	do.	
Do.	491	McGregor	do.	do.		Manila	
Do.	492	Light	do.	do.		do.	Great swarm in my house, May 24, 1921, as described in this paper.
Do.	494	McGregor	do.	do.		do.	Attacking documents in the Bureau of Science building.
Do.	498	do.	do.	do.		do.	
Do.	504	Light	do.	Cebu	Cebu	Cebu	Alates, April 20, 1921.
Do.	529	Mr. Gonzales	do.	do.	do.	do.	
Do.	535	Light	do.	do.	do.	do.	Alates flying, May 2, 1921.
Do.	536	do.	do.	do.	do.	do.	Do.
Do.	538	do.	do.	do.	do.	do.	Do.
Do.	586	Dr. J. W. Chapman and Light	do.	Negros	Oriental Negros	Above Luzuriaga	
Do.	588	do.	do.	do.	do.	do.	Alates, May 11, 1921.
Do.	589	do.	do.	do.	do.	Dumaguete	

Complete collection records of Coptotermes vastator sp. nov.—Continued.

Collection.	No.	Collector.	First reported.	Island.	Province.	Locality.	Remarks.
Author's	593	Dr. J. W. Chapman and Light	This paper	Negros	Oriental Negros	Dumaguete	Entering beams well coated with creosote.
Do	594	do	do	do	do	do	Alates flying, May 12, 1921.
Do	598	do	do	do	do	Polo Plantation	Destroying "palma brava" floor.
Do	597	do	do	do	do	Above Luzuriaga	Alates flying.
Do	625	Mr. P. Cartagena	do	Panay	Iloilo	Oton	Eating clothing in trunk.
Do	638	McGregor and Light	do	Luzon	Bataan	Mount Mariveles	
Do	646	do	do	do	do	do	
Do	704	Light	do	do		Manila	
Do	711	Mr. Primitivo Sustento	do	Panay	Iloilo	Santa Barbara	
Do	737	Mr. Ramon Nicdao	do	Luzon	Pampanga	San Fernando	
Do	738	do	do	do	do	do	
Do	739	do	do	do	do	do	
Do	764	Mr. Felino Fernando	do	do	Bulacan	Malolos	
Do	782	Miss Teopaco	do	do	Pampanga	San Fernando	
Do	783	do	do	do	do	do	
Do	784	McGregor	do	do		Manila	Alates flying.
Do	785	do	do	do		do	Alates flying, May 6, 1921.
Do	790	Miss Bernardo	do	do	Bulacan	Malolos	
Do	795	Miss Hernandez	do	do		Manila	
Do	818	Light	do	do		do	University Hall, University of the Philippines.
Do	822	Garcia and Light	do	do	Manila	do	Attacking flooring, second floor, Bureau of Printing building.
Do	824	do	do	do		do	Attacking cattle sheds, Pandacan Quarantine Station.
Do	825	Light	do	do		do	Attacking living papaya tree through roots.
Do	826	Gregorio Lopez	do	do		do	

Do	835	McGregor	do	do		do	Attacking Bureau of Science building.
Do	836	do	do	do		do	Alates in nest, April 21, 1921, Bureau of Science building.
Do	837	do	do	do		do	Alates flying, April 21, 1921.
Do	853	Light	do	do		do	Alates flying, April 12, 1921.
Do	855	do	do	do		do	
Do	857	Ramos	do	do	Mountain	Moncayan	Workers attacked by fungus.
Do	858	do	do	do		do	Do.
Do	868	do	do	do		do	From open pine forest.
Do	869	do	do	do		do	
Do	870	Mr. Sabino Garduque	do	do	Cagayan	Claveria	Attacking books in house.
Do	878	Light	do	do		Manila	Attacking "jarra wood" posts, Bureau of Forestry building.
Do	882	do	do	do		do	Attacking lauan, pine, redwood, and ipil in house.
Do	876	Dr. F. X. Williams	do	do	Laguna	Los Baños	Attacking house.
Do	904	Mr. Jose Coligado	do	do		Lilio	
Do	905	do	do	do		do	
Do	906	do	do	do		do	
Do	917	Mr. R. Flores	do	do	Pangasinan		
Do	925	Light	do	do		Manila	Alates flying, February 28, 1922.
Do	926	do	do	do		do	Alates flying, April 22, 1922.
Do	947	McGregor	do	do		do	Alates flying, February 16, 1922
Do	948	Light	do	do		do	Alates flying, February 20, 1922.
Do	951	do	do	do		do	Alates flying, April, 1922.
Do	970	McGregor	do	do	Pangasinan	Alaminos	
Do	973	Taylor	do	Tablas	Romblon	Odiongon	
Do	978	do	do	Marinduque	Tayabas	Boac	
Do	985	do	do	Tablas	Romblon	Odiongon	
Do	1002	McGregor	do	Luzon	Pampanga	Mount Arayat	
Do	1010	do	do	do		Manila	Alates flying, April 23, 1923.
Do	1137	Taylor	do	Mindanao	Cotabato	Milbuk	
Do	1170	do	do	do	do	Luan River	

Complete collection records of Coptotermes vastator sp. nov.—Continued.

Collection.	No.	Collector.	First reported.	Island.	Province.	Locality.	Remarks.
Do	1180	Taylor	This paper	Mindanao	Cotabato		
Do	1191	do	do	do	do		
Do	1210	do	do	Palawan	Palawan	Puerto Princesa	Tatayan Island.
Do	1220	do	do	Mindoro	Mindoro	Mangarin	
Do	1229	do	do	Palawan	Palawan	Puerto Princesa	
Do	1232	do	do	do	do	do	
Do	1253	do	do	do	do	Sir J. Brooke Point	
Do	1257	do	do	do	do	do	
Do	1266	McGregor	do	Luzon	Ilocos Norte	Bangui	
Do	1267	do	do	do	do	Piddig	
Do	1320	do	do	do	do		
Taihoku	[a] 1323	do	do	do		Manila	*C. formosanus* Oshima, 1920.
Author's	1331	do	do	do		do	
Do	1336	do	do	Samar	Samar	Loquilocon	
Do	1337	do	do	do	do	do	
Do	1338	do	do	do	do	do	
Do	1421	F. X. Williams	do	Luzon	Laguna	Los Baños	Alates flying, May 26, 1924.

[a] My collection.

C. parvulus (possibly belongs in first group), and *C. travians*. To this difficult group *C. vastator* belongs. The third group, in which the soldier's head is considerably larger, includes in the Oriental Region as yet only *C. dobonicus*. As the descriptions of the species concerned stand at present it is impossible to determine with satisfaction the different species of the group to which *C. vastator* belongs on the basis of soldier characters. Pending the much-needed revision of this group, which I hope to make, it becomes necessary for reasons given below to consider the common Philippine species a new species, *Coptotermes vastator*.

Of the *travians* group, *C. travians* and *C. bornensis* seem separated by no definite character, and they may be considered as extremely closely related if not the same species. *Coptotermes parvulus*, while approaching *C. travians* in size, because of its relatively shorter head and its geographical separation, is probably distinct from the others. *Coptotermes formosanus* is readily separated because it is generally larger with considerably longer and usually broader head. This leaves five species (namely, *C. travians, C. heimi, C. ceylonicus, C. gestroi,* and *C. vastator*), which on the basis of soldier characters as embodied in the systematic descriptions available seem very closely related. *Coptotermes gestroi,* which is sadly in need of redescription, seems separable on the basis of its smaller and particularly narrower pronotum; according to Holmgren the sides of the head are much more rounded. The geographical distance allows us to eliminate *C. ceylonicus* and *C. heimi,* although the presence of a single row of enlarged abdominal hairs on each tergum would differentiate *C. vastator* from these species, which according to Holmgren have two, as well as from *C. travians* which according to Holmgren has none. The much shorter pronotum length given by Holmgren would also tend to separate *C. travians* from *C. vastator.*

The characters of the adults are unknown for *C. bornensis, C. parvulus,* and *C. gestroi.* From *C. travians* the new species seems clearly differentiated by having twenty to twenty-two antennal segments and greater head and pronotum size. The smaller size of *C. vastator* clearly differentiates it from *C. formosanus, C. robustus, C. ceylonicus,* and *C. menadoensis* Oshima. With *C. heimi* and *C. havilandi* the new species seems to form a group of medium-sized termites. The pronotum seems longer in *C. vastator* (0.85 millimeter as compared with 0.72 millimeter and 0.76 millimeter in *C. heimi* and *C. havilandi,* respec-

tively). Other apparent differences from *C. heimi* Wasmann are that antennal segment IX in *C. vastator* is approximately spherical, that the pronotum is not distinctly notched in the anterior margin, and that the median is branched distally. Other apparent differences from *C. havilandi* Holmgren are that the size is considerably less (11 to 12 millimeters in *C. vastator* and 12 to 13.5 millimeters in *C. havilandi*), the abdomen is smoky brown not reddish, the head is considerably smaller, and the pronotum is considerably narrower and longer.

It seems worth while to give the complete collection records of this, the most-important Philippine species. I take this opportunity to thank the many persons named in the records who helped to accumulate this splendid collection. Many of them were members of my classes in the University of the Philippines.

BIOLOGY

It will be seen that collections from approximately one hundred fifty colonies of *C. vastator* are available for study, far more material than is available for any other species of the genus. These include about twenty-five collections of alates of which about twenty were made at time of swarming and hence consist of alates alone. Five collections containing alates were made from the colony and include workers, soldiers, and alates. In only one is the queen present (No. 265). This scarcity of royal individuals is due to the subterranean location of the nest of the species of this genus.

This extensive material is being used in a careful, much-needed study of the variation within a single species of termites. Such a study should be complemented by studies of variation among the thousands of individuals of a single colony at a given time and variation within the same colony at intervals over an extended period. Such studies will be of the greatest systematic value as well as of theoretical significance.

The data at hand show that the swarming period for alates begins as early as the middle of February and extends to the end of May. That less numerous emergences occur into June seems certain. That the definitive swarming takes place during the period of the preliminary showers of the opening rainy season seems also certain.

I am told by Filipino friends that there exists a local "superstition" that a flight of termites will be followed by a heavy rain. This is no superstition, however, but a record of observed fact. That such swarmings occur under conditions of baro-

metric pressure, temperature, and humidity such as precede, coincide with, or follow the first heavy rains of a wet season is an observation which I have made for this and other termite genera in the Philippines, China (Fukien Province), and California, and which has been recorded by numerous students of termites the world over. The same observation made by many Filipinos in times past has given rise to the so-called superstition.

It is interesting to note further, as instancing rather unusually keen observation and correlation, the common knowledge among Filipinos that the many diverse types of termites (soldier and worker castes of many genera) are related. The common name "anay" is unhesitatingly applied to them all with the single exception of the type that is found in isolated boards in houses, as *Cryptotermes cynocephalus* Light and *Planocryptotermes nocens* Light, which are called "gorgojo" or "buc buc" and confused with boring-beetle larvæ which they strongly suggest. Here, as is generally true elsewhere, however, the winged termite is not connected with the other castes, from which it differs markedly, but is given the name (so I am told by my Filipino pupils) of "gumgum" in Tagalog and "alibusbus" (Leyte) and "obus" (Cebu) in Visayan.

It seems worth while in this connection to include my journal accounts of a remarkable swarming of *C. vastator* that occurred in the house in which I was living on Gral. Luna Street, Manila.

Date of swarming: May 24, 1921, 6 to 7.30 p. m.

Weather conditions: Cloudy, close, very slight showers, thunder in the distance, heavy showers later during the night.

Swarming took place successively from various parts of the house. Dirt galleries, not present or at least not conspicuous previously, had been built out at several points along door posts etc. From projecting portions of these as well as from cracks between nearby boards the winged adults were boiling out when first observed. Guarding these openings were numerous soldiers making a solid line with heads facing out. These seemed to have nothing to do with the actual emergence of the adults but to be a guard to prevent entry of that terrible enemy of the termite, the true ant. Many of these as well as a few workers were carried out by violence of the emerging alates. This theory of the function of the soldiers at these openings seems weakened by the observation that one of these openings was still unclosed thirty minutes after completion of the flight, and no soldiers were in sight. This observation was made at one point only, however, and is not conclusive.

In one room where the floor was badly attacked the alates swarmed through the cracks in immense numbers and formed a struggling mass about 3 feet in diameter and 2 inches deep. The sound made by the wings of the thousands of emerging, struggling, and flying individuals was very suggestive of the soft yet pervasive sound of a first heavy snow.

The emerging alates, demonstrating remarkably strong positive phototropism, flew at once toward the nearest or strongest source of light. They were lead throughout the house by turning lights on and off in series. When two lights of the same magnitude were on in adjoining rooms the lower members of the swarms were not directly under either light but each swarm bent outward toward the bottom in the direction of the other light, their positions being a resultant of the attraction of the two lights. This could be clearly demonstrated by doubling the lights at one point when this living curve moved toward the stronger light until a new equilibrium was attained considerably nearer the brighter light.

They were strong and rapid flyers. A great cloud of thousands about the light near an open door would sweep out of the door in a few moments were the light turned off. Especially rapid was this movement when an outdoor light was switched on and the inner light was switched off. What became of them after they left the house I could not determine. That they fell prey in very great part to ants, lizards, bats, rats, etc., seems certain as I have observed to be the case on many occasions and as have many other observers in many regions. But few of them at first reached the lights of the next house a scant 50 feet away. Later they appeared there in large numbers, whether from the house itself or from our swarm was not determined.

The emergence at any particular point seemed to last not longer than twenty minutes, but termites were emerging at some point for the better part of an hour, and a few congregated about any lights for an hour after that. Similar swarms occurred at many points of the city and no doubt over a much wider area corresponding to similar conidtions.

I saw but little evidence of mating. Of courting movements of the female such as described by Fuller (1915), I saw nothing. Wings were lost by many individuals but apparently more from accident than in the normal course of events. Numerous individuals had hidden themselves under books on a woven bam-

boo center table where many had lost their wings, and a few exhibited the mating movements, the male following immediately behind the female with his head touching the tip of the female's abdomen and his antennæ continually playing on its dorsal surface. One such pair when placed on moist earth in a tin continued these movements. They ran round and round the rim of the tin and under the edges of the larger pieces of earth as if investigating.

Numerous specimens were caught in open tin boxes moved back and forth through the swarms under light. These boxes were left tightly closed and when opened in the morning to my surprise all the termites were found very active and still winged. No sign of mating was noted. In the other box there was some moisture and many individuals had lost their wings, whether normally or by getting them caught in the moisture I do not know, but probably the latter. No sign of mating here either.

At about 10 a. m. the contents of the first box were emptied into a large aquarium jar in which had been placed moist earth and a piece of packing pasteboard. No signs of mating were noted for some time and no shedding of wings. Later one pair was seen in mating attitude and one or two shed their wings. Apparently either the proper stimulus for wing shedding was lacking or the period of normal reaction had passed. As to mating, it seems probable that the close intermingling of the sexes for so long a time had pretty well distributed the scent.

Numerous test tubes were fitted up according to the method of Oshima (1919) and a male and a female placed in each. Digging operations were undertaken at once in spite of wings. Food (cotton, filter paper, fine shavings, and excelsior) seemed to confuse them and retard operations. When observed at 2, 3, and 5 p. m. they were mostly on the surface due, probably, to the retarding presence of wings. One pair had shed the wings. One pair had made a hole large enough to hold the female, but she had become fast by her wings. These I cut off 1 to 2 millimeters behind the wing stumps. On being returned to the test tube they began work more energetically than ever, the female going into the hole and the male behind her pushed and nipped at the end of her abdomen relentlessly forcing her on for a time. Later he widened the upper part of the cavity, but soon returned to his former tactics which forced the female on to greater effort and prevented her returning if she would. This excavation, except at first, is not by actual removal of dirt particles but by pushing them aside and manip-

ulating them first with the mouth parts and afterward with the feet. The male, by dint of strenuous efforts, turned around, thus making the upper part of the cavity quite wide, and emerging ran over to the piece of cotton at one side, but soon returned to the cavity.

Later, about 1.30, the specimens from the other box were placed in the jar. Here the wingless individuals as well as a wingless female and a winged male began mating. I failed to note mating on the part of two winged individuals or of winged female and wingless male. It would seem that dealation, even though abnormally accomplished, allows for mating and that dealation of the female is accompanied by some change necessary to stimulate the male to mating which may take place although the latter is still winged.

Many couples dug themselves in, but for some reason they were unable to succeed in establishing themselves, perhaps because of lack of food. Many of the couples which set up their abode in the cells of the packing board soon began to eat and to close their cells with chewed particles of the pasteboard. The observation, that the pair forage for themselves, agrees with that of Oshima (1919) as against the common opinion that the royal pair subsist and feed the first brood of wokers on food stored within their bodies.

Many of the females laid one or more eggs, but the experiment was soon stopped because of lack of time and the attack of fungus.

ECONOMIC IMPORTANCE

It may safely be said that if all termite species except *C. vastator* disappeared from the Philippines the major economic problem would be little changed. This species is common throughout the Islands. The soldier in this genus has as a special characteristic, a greatly developed cephalic gland and, on attack, a milky white acid secretion is thrown out in a copious drop through the large anteriorly directed circular fontanel which lies at the end of a frontal tube just above the base of the mandibles (text fig. 4). This not only furnishes an effective protection against their arch enemies, the true ants, but it has been maintained that the acid secretion is used in dissolving the lime in mortar thus giving access to the wooden portions of buildings otherwise unapproachable. Furthermore, the colonies are large with great numbers of permanent workers. Their nests are well protected, usually in the ground, but sometimes within the timber attacked. They exhibit the greatest ability and persistence

in reaching the wooden structures of buildings taking advantage of any crack or faults in cement or cracks in resistant or treated timbers, or eating a way through timbers ordinarily immune to reach more-favored food supplies, and always and most persistently building over and around obstacles to reach softer woods of the superstructure. Numerous instances of this ability might be cited. In the detention shed of the cattle quarantine station of the Bureau of Agriculture of the Philipine Islands, located in the outlying district of Pandacan, Manila, we have a very fine example of what this termite will do to obtain wood supply. The sheds have a concrete foundation and concrete pillars. Through the center run two cement mangers. Bolted to the tops of the mangers are some twenty-six supporting posts of jacal bolted above to timbers of apitong supporting the roof (Plate 8, fig. 1). The roof timbers of all the sheds were badly attacked and in many cases immediate replacement was necessary. Estimates by the Bureau of Public Works set the cost of repair at 100,000 or more pesos. In many of the sheds no ground connection is noticeable. The covered galleries appearing here and there on the roof timbers, however, are significantly composed of the usual mixture of earth and fæcal wood waste (Plate 8, fig. 1; Plate 9, fig. 1). A careful search in several of the sheds showed the method of approach. Faults in the concrete, some of them exposed and some of them internal, allowed the termites to pass the concrete foundation (Plate 9, fig. 3). Once through this they built their covered ways, when necessary, over the concrete to the bases of the yacal posts. Now yacal is a termite resistant wood, but by taking advantage of cracks or where cracks were lacking, by eating a passageway they reached the softer, susceptible apitong, which they completely riddled (Plate 9, fig. 2).

In several large concrete buildings in Manila, such as those of the Philippine Normal School and the Student Young Men's Christian Association this species of termite is to be found destroying the woodwork on the upper floors. In these buildings the concrete lower floor rests on the ground, and the termites enter through cracks. Wherever the floor is raised above the ground the entry of the termites is difficult, yet even under those conditions they build their covered passageways up the walls and take advantage of any opening to enter the building, particularly from the inside, for darkness and dampness are to their advantage. In the Freer Laboratory of the University of the Philippines where the construction is of this type and

there are apparently no cracks, *Coptotermes* entered between a gas pipe and the casing pipe and eating their way through an ipil plank were beginning the destruction of the softer white lauan desks. Filling the aperture with paint was sufficient to stop this attack, those already within the building soon succumbed when shut off from below. I am indebted to Mr. Sylvester, constructing engineer of the Bureau of Public Works, Manila, for another example of the quickness of *Coptotermes* to take advantage of any opening. The Municipal Building of Tayabas was found to be very seriously attacked; the roof was so badly damaged as to require extensive repair. An investigation of this building showed that the concrete columns had been left open above to the roof and that the wooden frame around which the columns had been constructed had been left within the columns, as is usual, thus furnishing a most satisfactory stairway whereby the termites might reach the roof timbers.

In common with all other true subterranean termites, that is all seriously harmful termites, *Coptotermes* has one vulnerable point. This is the necessity of maintaining a ground connection, not only because the central nest with the royal pair and young is usually there, but also because moisture is necessary to continued existence. It may be also that the soil which they freely use mixed with excreta in making their covered passageways is in some other way necessary to the successful development of the colony. Whatever the causes may be, it seems certain that in most, if not all, cases a shutting off of the ground connection results in the death of those in the building and prevents further destruction. Here, then, is the crux of the termite problem. How, in case of buildings already attacked, to isolate the superstructure from the ground and to build in such a manner as to prevent entrance from the ground or the reaching of the ground by colonies which may arise in the building from chance entrance of winged pairs if, as is claimed by Oshima, such an origin is possible.

While I am convinced that a thorough study of such cases would demonstrate a ground connection, it must be noted that instances have been reported of flourishing colonies doing considerable damage where no ground connection could be demonstrated. Certainly those of *Coptotermes formosanus* established in ships have no such connection. If we keep in mind their almost uncanny ability to penetrate considerable thicknesses of concrete by taking advantage of all cracks and faults, and,

keeping out of sight, to attack the upper floors of large buildings and to damage the wooden structures, I believe we are justified, in the absence of convincing proof to the contrary, in acting upon the belief that a ground connection is necessary and in so treating attacked buildings and in so constructing new buildings that the possibility of such ground connection is minimized or eliminated.

No doubt faultless concrete construction of the proper type, as described by Oshima (1919) and Woodeson (1921), would

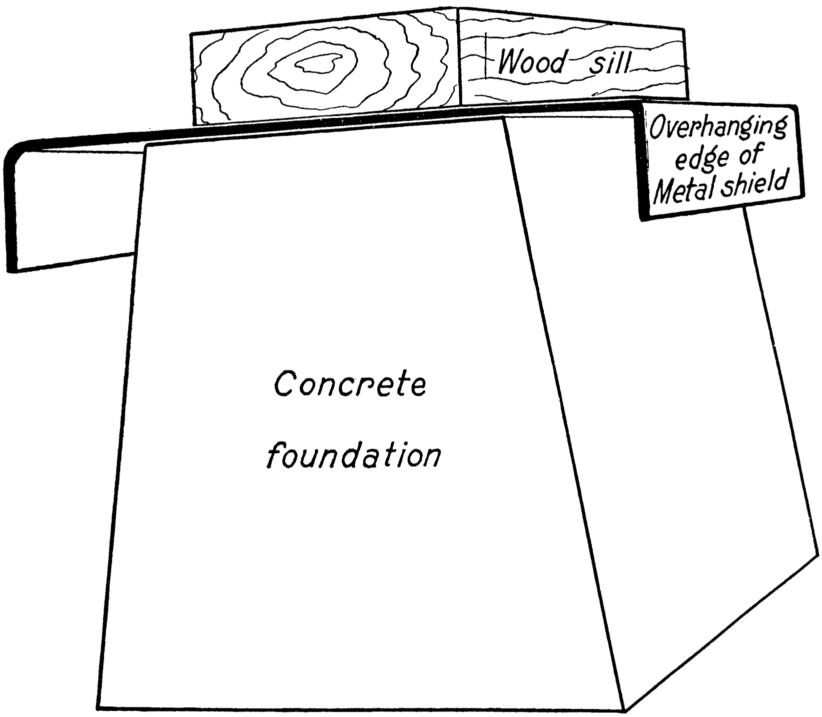


FIG. 6. The termite shield in crude practical form for small houses as in use in certain parts of California. Kindness of California-Hawaiian Sugar Refinery, Crockett, California.

eliminate a considerable amount of termite damage; but conditions in the Tropics are not conducive to such construction, and a single fault may give entry to the entire building and be extremely difficult if not impossible to find and to remedy. It would seem necessary, therefore, to have recourse to some more certain method of isolating the superstructure.

To fill this need I have devised what I have called the "termite shield." This consists in its most radical form of a continuous metal layer through house post or foundation wall continued

externally as a hanging edge (text figs. 6 to 8). Where it is necessary to have a firm bond between posts and superstructure, as in regions subject to earthquakes it might be necessary to

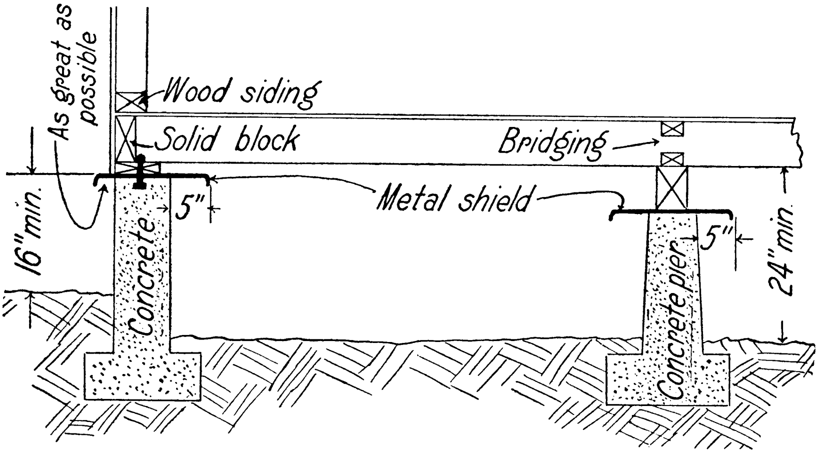


FIG. 7. Plans for protection of buildings against subterranean termites. Modified silghtly from plans issued by Mr. Walter Putnam, city superintendent of buildings, Pasadena, California. Used by permission of Mr. Putnam.

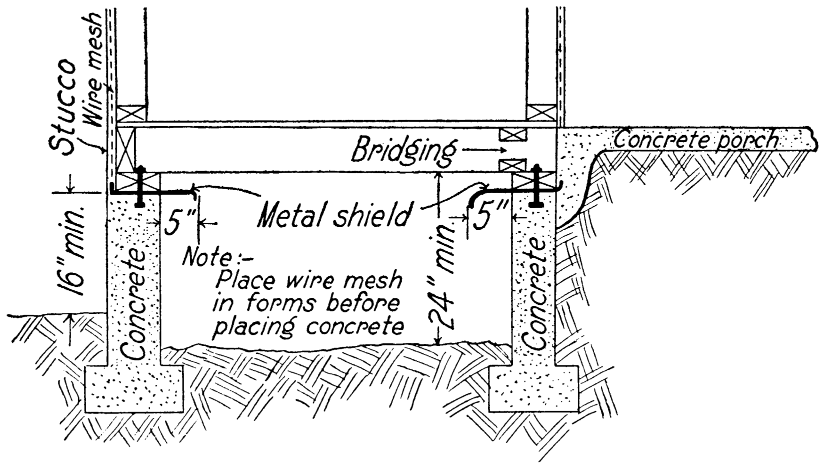


FIG. 8. Plans for protection of stucco building against subterranean termites. Modified from plans issued by Mr. Walter Putnam, city superintendent of buildings, Pasadena, California. The chief modification is in ending the stucco at the upper level of the concrete foundation. The color scheme may be preserved by a wash on the foundation surface to correspond with the stucco.

construct the shield of cast iron or steel with a double spur-box to allow of the bolting below and above. The objections to this are the cost and the danger of rusting out. Bolting through galvanized iron proves satisfactory (text figs. 8 and 9) if the

hole is soldered. Where earthquakes are not common a device similar to that in use in Australia and South Africa consisting of a heavy galvanized iron cap for house posts will be effective (text figs. 6 to 8). In such cases if the pillar is of cement and the cap in the shape of an inverted cup it should be cheap, effective, and lasting. If the post is of wood even though both of the resistant type and thoroughly termite proofed, the probabilities are that the termites will in time penetrate it and if it be *Coptotermes* they may even dissolve away the metal by means of the acid secretion of the soldier and make their entry into the superstructure.

A device theoretically less satisfactory but much less expensive and more durable, one which avoids the engineering difficulty of completely severing the concrete pillar or wall, and which will probably be as effective consists of a similar arrangement which extends only a few inches into the concrete of the pillar or foundation wall. I am forced here to depend on the information which I receive from the cement engineer that cracks in pillars and foundation walls are superficial and that such a device would prevent entry through them. Such a device could be made of heavy galvanized iron, would be cheap, durable, and effective, and, I am told by architects, would be amenable to decorative treatment such as to prevent its marring the architectural effect.

Experiments to test the effectiveness of the termite shield as a protection against the American species of the genus *Reticulitermes* are projected by the Termite Investigations Committee (Light, 1929). Similar tests should be carried out in Manila where the densely infested Pandacan region offers a splendid opportunity and in Honolulu or Formosa where *Coptotermes formosanus* presents difficult problems.

LITERATURE CITED

FULLER, CLAUDE. Observations on some South African termites. Ann. Natal Mus. 3 (1925) 329–504.

LIGHT, S. F. A new and more exact method of expressing important specific characters of termites. Univ. Calif. Publ. Ent. 4 (1927) 75–88.

LIGHT, S. F. Termites and termite damage. Univ. Calif. Coll. Agr. Exp. Station Circular 314 (1929).

OSHIMA, M. Formosan termites and methods of preventing their damage. Philip. Journ. Sci. 15 (1919) 319–383.

SNYDER, T. E. Preventing damage by termites or white ants. U. S. Dep. Agr. Farmers' Bull. 1472 (1926).

WOODESON, A. Termites or white ants and their attacks on buildings. Trans. Eng. Assoc. Ceylon (1921).

ILLUSTRATIONS

PLATE 1

Coptotermes vastator sp. nov., head of alate to show head outline and antennæ, photomicrograph, × 50.

PLATE 2. COPTOTERMES VASTATOR SP. NOV., PHOTOMICROGRAPHS.

FIG. 1. Portion of head capsule of alate, greatly enlarged to show ocellus, antennal spot, antennal fossa, a few facets of the compound eye, and the first segments of the antennæ, × 771.
2. Head of alate to show surface structures, × 43.
3. Pronotum of alate, × 43.
4. Base of forewing, × 43.
5. Base of hindwing, × 43.

PLATE 3

Coptotermes vastator sp. nov., photomicrograph of entire forewing, × 20. Note the absence of a costal strip and the very slight pigmentation distal to the suture.

PLATE 4

Coptotermes vastator sp. nov., photomicrograph of mandibles of alate, × 140.

PLATE 5. COPTOTERMES VASTATOR SP. NOV., ALATE, PHOTOMICROGRAPHS.

FIG. 1. Foreleg, × 140.
2. Region of fontanel, × 795.

PLATE 6. COPTOTERMES VASTATOR SP. NOV., SOLDIER, PHOTOMICROGRAPHS.

FIG. 1. Head, dorsal view, ca. × 28.
2. Left mandible, ca. × 80.
3. Antenna, left mandible, and labrum, ca. × 35.

PLATE 7. PHOTOGRAPHS OF WORK OF COPTOTERMES VASTATOR SP. NOV. IN WOOD OF BOX IN BASEMENT OF UNIVERSITY HALL, UNIVERSITY OF THE PHILIPPINES, MANILA, P. I.

FIG. 1. Thin superficial layer torn away to show workings and frass.
2. End of sawed portion of same, somewhat enlarged.

PLATE 8. PHOTOGRAPH OF WORK OF COPTOTERMES VASTATOR SP. NOV. IN CATTLE SHEDS OF THE PANDACAN QUARANTINE STATION, MANILA, P. I.

FIG. 1. Roof of one the sheds showing covered runways on timber.
2. Portion of nest taken from these boards, enlarged.

PLATE 9. WORK OF COPTOTERMES VASTATOR SP. NOV. IN CATTLE SHEDS OF THE PANDACAN QUARANTINE STATION, MANILA, P. I.

FIG. 1. Covered runway built down a concrete pillar of cattle shed, retouched.

2. Portion of board removed from roof of cattle shed showing nest structure, enlarged.

3. Portion of manger in cattle shed showing earthen galleries running from a crack in the concrete over the concrete manger to the pillars of hardwood through which termites built passageways to the lauan timbers of the roof.

TEXT FIGURES

FIG. 1. *Coptotermes vastator* sp. nov. alate, head capsule in dorsal view, ca. $\times$ 60.

2. *Coptotermes vastator* sp. nov. alate, sketch of forewing.

3. *Coptotermes vastator* sp. nov., head of soldier from type colony, dorsal view.

4. *Coptotermes vastator* sp. nov., head of soldier, side view.

5. *Coptotermes formosanus* Shiraki, from Honolulu, forewing. Note that it is larger than the forewing of *C. vastator* (see fig. 2 drawn to the same scale) and has more pigment at the base and in the form of a "costal stripe."

6. The termite shield in crude practical form for small houses as in use in certain parts of California. Kindness of California-Hawaiian Sugar Refinery, Crockett, California.

7. Plans for protection of buildings against subterranean termites. Modified slightly from plans issued by Mr. Walter Putnam, city superintendent of buildings, Pasadena, California. Used by permission of Mr. Putnam.

8. Plans for protection of stucco building against subterranean termites. Modified from plans issued by Mr. Walter Putnam, city superintendent of buildings, Pasadena, California. The chief modification is in ending the stucco at the upper level of the concrete foundation. The color scheme may be preserved by a wash on the foundation surface to correspond with the stucco.

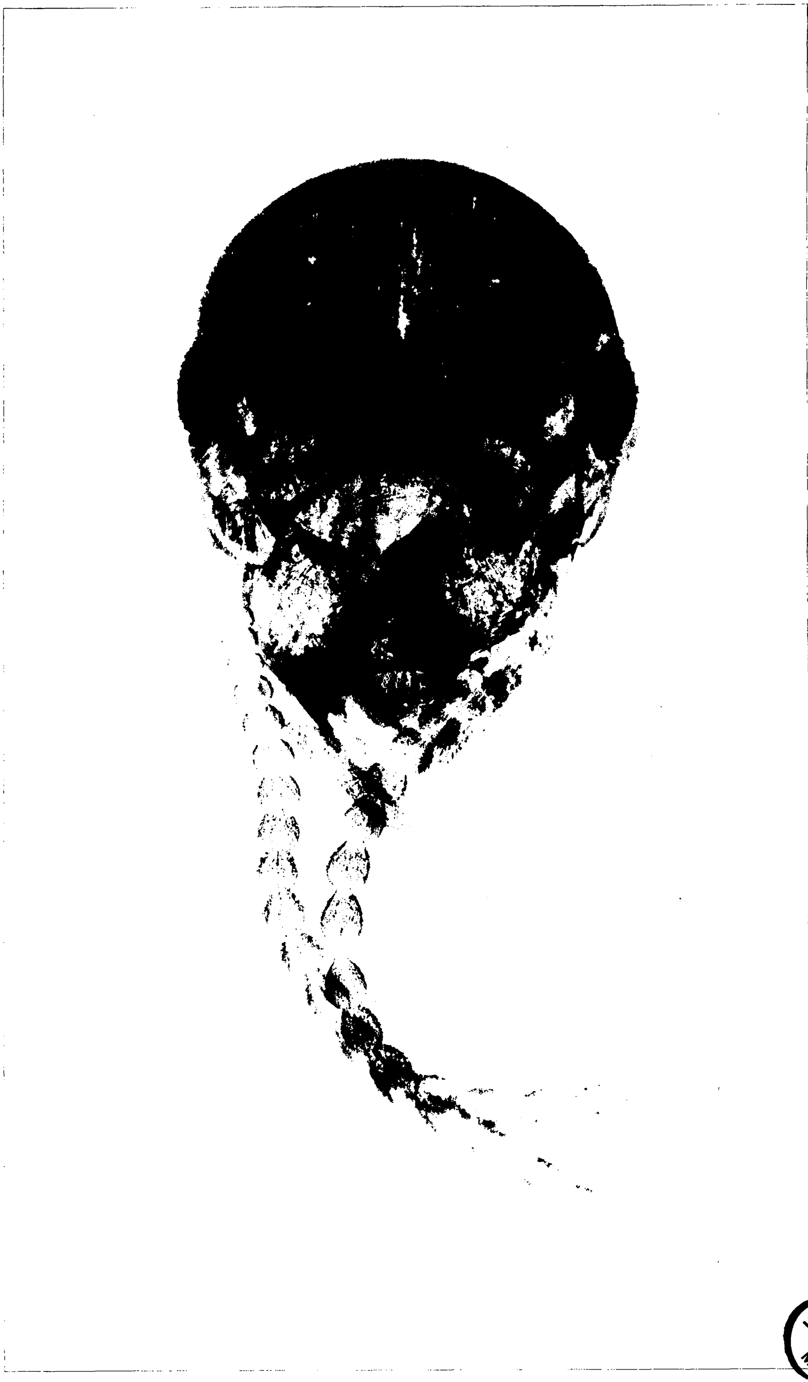
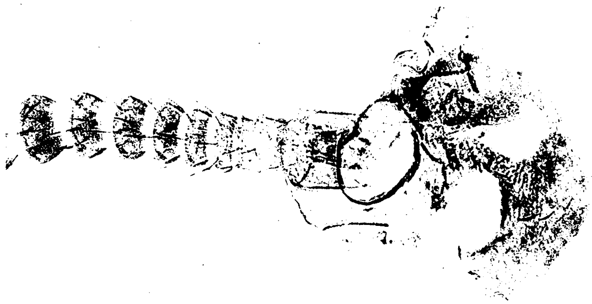


PLATE 1.



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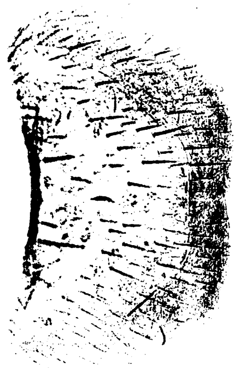

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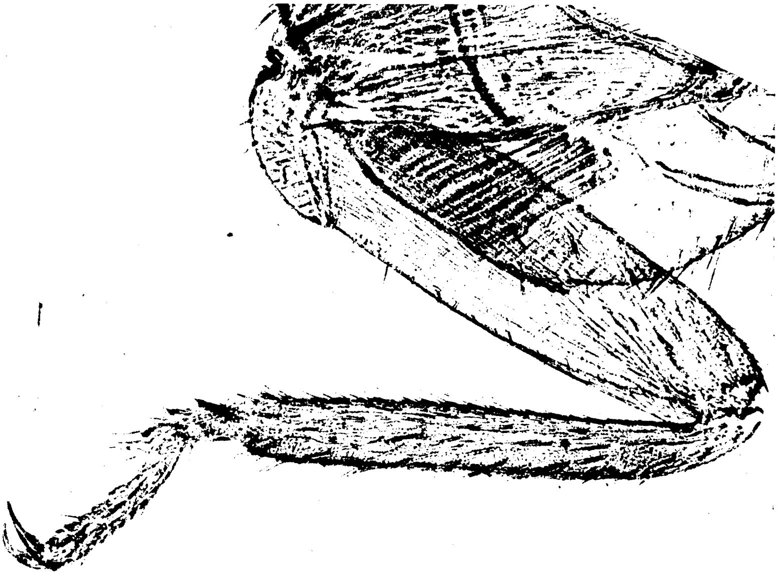
PLATE 2.

PLATE 3.

PLATE 4



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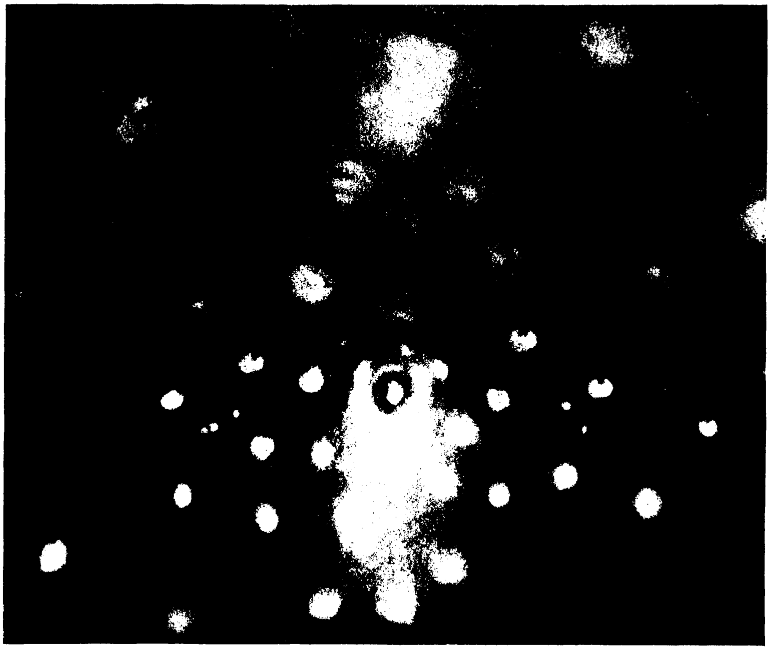

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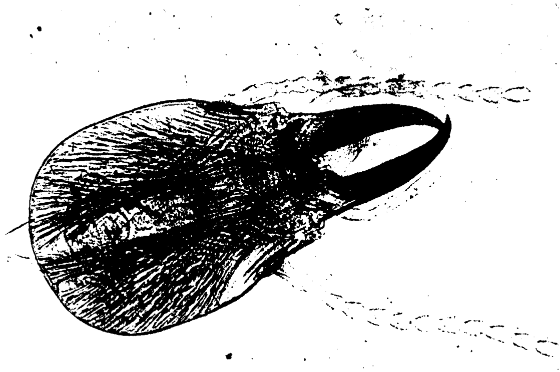

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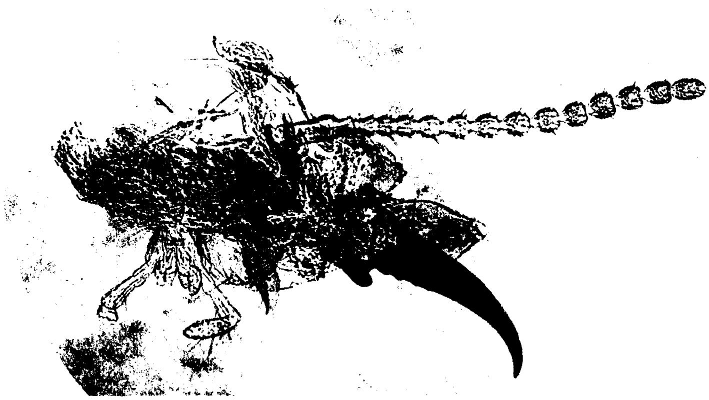

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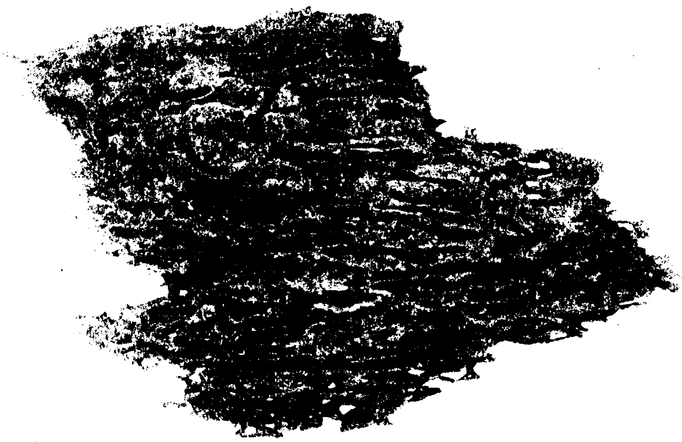
PLATE 6.

1

2

PLATE 7.

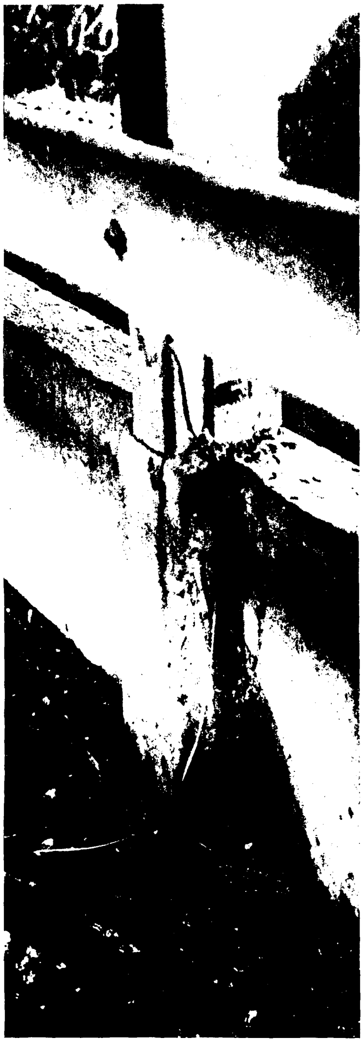
1



2

PLATE 8.

1



3

2

PLATE 9.

DIE ANTHICIDEN DER PHILIPPINEN, II

Von H. KREKICH-STRASSOLDO

Graz, Austria

ZWEI TAFELN

Als ich den ersten Teil meiner Studie über die Anthiciden der Philippinen [1] veröffentlichte, lag mir im Wesentlichen nur dasjenige Material vor, das mir von Herrn Dr. Charles Fuller Baker in entgegenkommender Weise zur Verfügung gestellt worden war. Seitdem ist eine grosse Anzahl Anthiciden, die Herr Böttcher in den Kriegsjahren auf den Philippinen sammelte, teils direkt in meinen Besitz übergegangen, teils mir von Museen Deutschlands zum Studium überlassen worden.

Die Durchsicht dieses wertvollen Materials ergab eine stattliche Anzahl neuer Arten und neuer Fundorte bereits bekannter Arten und soll das Ergebnis meiner Untersuchungen in den nachfolgenden Zeilen niedergelegt worden. Hiebei halte ich mich an die im ersten Teile meiner Arbeit eingehaltene Reihenfolge.

NOTOXUS

Auch in den neuen Fundergebnissen fand sich kein einziger Vertreter dieses Genus vor, so dass anzunehmen ist, dass es auf den Philippinen überhaupt nicht vorkommt.

MECYNOTARSUS

Herr M. Pic [2] hat zwei *Mecynotarsus* aus Manila beschrieben: *Mecynotarsus humeralis* und *Mecynotarsus baeri.*

Ich habe 21 Mecynotarsus, die in den Monaten März bis Mai in Manila erbeutet wurden, untersucht. Diese Art ist sehr veränderlich in der Färbung; ganz dunkle und ganz lichte Färbung mit zahlreichen Zwischenstufen wechseln ab. Es war mir nicht möglich, einwandfrei zu bestimmen, um welche der zwei von Pic beschriebenen Arten es sich handelt. Nach dem Autor soll sich *M. baeri* vom *M. humeralis* durch das längere Horn unterscheiden. Dieses Merkmal ist aber nicht massgebend, da die ♂ ♂

[1] Philip. Journ. Sci. 27 (1925) 515–535, 3 pls.

[2] Ann. Soc. ent. France (1902) 643, 644.

ein längeres, die ♀ ♀ ein breiteres kürzeres Horn aufweisen. Ich neige daher der Ansicht zu, dass wir es mit einer einzigen Art zu tun haben, der der zuerst publizierte Name: *Mecynotarsus humeralis* Pic zukommt.

FORMICOMUS (ORTHAUCHEN)

Formicomus bifasciatus Pic von Böttcher in folgenden Lokalitäten erbeutet; N. Luzon: Kalinga (I [3]), Lubuagan (I), Buranao (V), Cabugao-Imugan (4,000 Fuss, VI, VII); Montalban (III).

FORMICOMUS INGENS sp. nov.

Gross, schwarz mit metallischem Glanze, nur die Beine und namentlich die Tarsen mit blutrotem Scheine. Grösser als *F. bifasciatus* Pic, wie dieser mit zwei, aus weissen Haaren bestehenden Binden auf den Flügeldecken, Beide Binden sind jedoch wenig dicht und von der Naht weit entfernt.

Kopf glänzend, grob und zerstreut punktiert, mit abstehenden dunklen kürzeren und längeren Borstenhaaren nicht dicht bekleidet. Augen gross, vorstehend, gerandet; längs des oberen Augenrandes eine seicht Rinne. Fühler sehr lang und sehr schlank; zweites Glied sehr kurz, Endglied etwas länger als das zehnte. Halsschild länger als breit, vorne gerade und so breit wie der Kopf mit den Augen; covex, knapp vor dem Basalrande geschmälert; Seiteneindruck breit, seicht; glänzend, mit einer *vollständigen Längsrinne;* vorne kaum, gegen die Basis gröber punktiert und querrunzelig. Einzelne abstehende weisse Borstenhaare.

Flügeldecken eiförmig; Basis zu den kurz gerundeten Schulterecken leicht abfallend; kein Posthumeraleindruck: Omoplaten nicht erhoben. Sehr zerstreut und fein punktiert und ausser den weissen Bindenhaaren mit dunklen Borstenhaaren spärlich bekleidet.

Beine sehr lang und kräftig. Vorderschenkel des ♂ an der Unterseite in der proximalen Mitte mit einem kurzen scharfen Dorne; die Vordertibien des ♂ sind an der Unterseite in der distalen Hälfte lappenförmig länglich ausgezogen und vor der bedornten Spitze kurz und leicht eingebuchtet.

Unterseite dunkel-bis rotbraun, glänzend, fein punktiert und fein behaart. Sichtbares Endsternit breit eingedrückt, mit

[3] Die römischen Zahlen bedeuten den Monat des Fanges.

einem dreispitzigen dunklen Lappen in der Mitte; unterhalb des Lappens ragt ein harpunenartiger Fortsatz hervor.

7 Millimeter.

Socorro. Ein-♂ in meiner Sammlung.

Offendar dem *F. insignis* (olim *maximus* Pic) nahestehend, jedoch als neue Art zu betrachten da in der Beschreibung des *F. insignis* der auffallenden Längsrinne am Halsschilde keine Erwähnung geschieht. Eine solche Rinne hat auch *F. albopictus* Kr.; dieser weist jedoch nur eine (vordere) weisse Haarbinde an den Flügeldecken auf.

FORMICOMUS BISPINOSUS Kr.

Formicomus bispinosus KR., Philip. Journ. Sci. 27 (1925) 518.

Böttcher fand in Surigao (VIII, IX) einige Exemplare dieser Art, die nur eine (die vordere) aus weissen Haaren bestehende Binde aufweisen. Die Gestalt des sichbaren Endsternites ist etwas verschieden von der Type, weshalb ich die betreffende Zeichnung bringe. Die ebenfalls von Böttcher in Dapa, Siargao (X), und Cabuntog, Surigao (IX), erbeuteten *F. bispinosus* haben dagegen zwei aus weissen Haaren geformte Binden an den Flügeldecken.

FORMICOMUS BÖTTCHERI sp. nov.

Dem *F. bifasciatus* Pic in der Gestalt und Färbung ausserordentlich ähnlich, jedoch schlanker und hauptsächlich dadurch auseinanderzuhalten, dass die Vorderschenkel des ♂ an der Innenseite keinen langen Dorn aufweisen, sondern höchstens eine leichte, spitze Anschwellung. Der Halsschild hat oberhalb des Basalrandes nicht 2 von einander entfernte Gruben, sondern eine quere glatte Einkerbung. Die Flügeldecken sind etwas schmaler und weniger dicht punktiert. Die vordere, aus weissen Haaren gebildete Binde ist schmaler und gegen die Naht zu kürzer. Die Beine weniger kräftig, rot durchscheinend.

Unterseite dunkelbraunrot, fein chagriniert und mit dünnen, gelblichen Härchen bekleidet.

5.6 Millimeter.

Mindanao: Surigao (II) (*Böttcher*).

FORMICOMUS CONSOCIATUS sp. nov.

Dem *F. bispinosus* Kr. und *bifasciatus* Pic änhlich, jedoch spezifisch verschieden und eher mit dem *F. appendicinus* Kr. verwandt.

Gross, schlank; Kopf, Halsschild und Beine schwarz mit blutrotem Schimmer; Flügeldecken ganz blau, glänzend, mit einer, aus weissen, zottigen, unregelmässig stehenden Haaren gebildeten, die Naht nicht erreichenden Querbinde im ersten Drittel.

Kopf eiförmig. Augen gross, ohne Randleiste, mässig vorstehend; Schläfen gleich hinter den Augen vermindert und in den langen Hals übergehend. Mit feinen Längsrippen bedeckt und mit feinen weissen Haaren längs und quer bekleidet; überdies einige abstehende Borstenhaare. Wenig glänzend. Fühler sehr lang, bis zum ersten Drittel der Flügeldecken reichend; alle Glieder—das zweite, sehr kurze ausgenommenfast von der gleichen Länge; Endglied etwas länger als das zehnte, spindelförmig.

Halsschild etwas länger als der Kopf mit dem Halse, wenig schmaler als der Kopf; vor der Basis leicht eingeschnürt, mit kräftigem, queren Seitene indrucke. Glatt, glänzend; zerstreut, nur gegen die Basis dichter und auch kräftiger punktiert; mit sehr feinen, bräunlichen Haaren, von denen wenige abstehen, spärlich bedeckt.

Flügeldecken länglich-elyptisch, etwa ein und ein halb mal so lang als der Kopf mit dem Halsschilde. Basis leicht zu den spitzen Schulterecken abfallend; an den Seiten gegen die Mitte mässig breiter. Kein Posthumeraleindruck. Omoplaten nicht erhoben. Schildchen länglich, spitz, in der Mitte eingedrückt. Kein Nahtstreifen. Fein und zerstreut punktiert und mit gelblichen, teilweise in Reihen stehenden, nicht ganz anliegenden Haaren sparsam bekleidet.

Beine sehr kräftig; alle Tibien und Tarsen dicht behaart. Vorderschenkel des ♂ mit starkem, leicht abgestutzten Zahne innen in der Mitte; die Vordertibien des ♂ distal verdickt und vor der Spitze scharf eingebuchtet.

Unterseite dunkelrotbraun, ziemlich glänzend; fein und dicht punktiert und fein gelblich behaart. *Am zweiten Sternit des ♂ zwei abstehende dornartige Fortsätze;* das sichtbare Endsternit des ♂ hat in der Mitte ein kugelförmige Erhebung.

7.5 Millimeter.

Mindanao: Mumungan. Buranan (V) (*Böttcher*).

FORMICOMUS EXCAVATUS Kr.

Formicomus bakeri Kr., Philip. Journ. Sci. 27 (1925) 519.

Es liegt mir ein ♂ aus der Insel Basilan und ein ♀ aus Zamboanga, Mindanao, vor. Beide mit deutlicher Längsrinne in der Mitte des Halsschildes und mit Gruben beiderseits des Vorderlobus desselben; allerdings sind diese Gruben weniger ausgeprägt.

Die Vorderschenkel des ♂ sind nicht bedornt, dagegen die Vordertibien an der Innenseite in der Mitte leicht geschwollen und vor der bedornten Spitze schwach eingebuchtet.

Ich bringe die Endsegmente und den Penis des ♂.

FORMICOMUS BAKERI Kr.

Formicomus bakeri Kr., Philip. Journ. Sci. 27 (1925) 519.

Auch von diesem *Formicomus* vermag ich heute die Zeichnung der Endsegmente des ♂ zu bringen.

FORMICOMUS HASTATUS sp. nov.

Gedrugen, gewölbt, glänzend; ganz dunkelrotbraun, die Flügeldecken mit metallischem Schimmer.

Kopf länglich-elyptisch; Augen gross, vorstehend; vor den Fühlerwurzeln erhobene, an der Stirne sich vereinigende Leistchen. Schläfen ziemlich lang und leicht convergierend, um, mit geringem Absatze, in den Hals einzumünden. Sehr zerstreut, eher grob punktiert und mit lichten kurzen Haaren sparsam bekleidet. Fühler sehr lang und kräftig; Endglied etwas länger als das zehnte, wenig spitz. Halsschild um die Hälfte länger als breit, etwas schmaler als der Kopf, stark gewölbt. Knapp vor der Basis eingeschnürt; Seiteneindruck kräftig. Oberhalb der Basis eine quere scharfkantige Erhebung; der Raum zwischen dieser und dem Basalrande sehr glatt und glänzend. Fein und sehr zerstreut punktiert, nur gegen die Einschnürung zu etwas rauher und quer; am vorderen Teile des Halsschildes eine schmale Längsrippe in der Mitte. Mit lichten, zum Teile ganz abstehenden kurzen Borstenhaaren schwach bekleidet.

Flügeldecken kurz (kaum ein und ein viertel mal so lang als der Kopf mit dem Halsschild) und um die Mitte sehr erbreitet. Basis zu den spitzen Schulterecken leicht abfallend. Kein Posthumeraleindruck. Omoplaten nich erhoben. Nahtstreifen kaum angedeutet. Sehr fein und sehr zerstreut punktriet und mit gelblichen Haaren sparsam bedeckt.

Beine lang, kräftig; alle Schenkel sehr verdickt. Vorderschenkel des ♂ mit langem spitzen-zahn in der Mitte der Unterseite; Vordertibien des ♂ distal breitlappig ausgezogen und vor der bedornten Spitze eingebuchtet; der Lappen trägt lange abstehende Haare. Unterseite dunkelbraum; Mittelbrust dicht chagriniert; sonst fein punktiert und schwach behaart.

4 Millimeter.

Iligan.

FORMICOMUS (VERUS)

FORMICOMUS PRIMITIVUS Kr.

Formicomus primitivus KR., Philip. Journ. Sci. 27 (1925) 520.

Neue Fundorte: Mindanao: Mumungan (*Böttcher*). Negros: Cuernos Mountains (*Baker*).

FORMICOMUS SIMULANS sp. nov.

Ungefähr von der Grösse unseres *F. pedestris.* Rossi. Glänzend, Kopf und Halsschild dunkelrotbraum bis schwarz, Flügeldecken schwarz mit bronzegrünem Schimmer, Mundteile, Fühler und Beine dunkelrostrot.

Kopf etwa so lang als breit. Augen gross, vorstehend; Schläfen kurz und gleich hinter den Augen zur breitbogigen Basis vermindert. Ziemlich grob und zerstreut punktiert, längs der Augen gerunzelt, mit gelben zum Teile abstehenden Borstenhaaren spärlich bekleidet. Fühler schlank, bis über die Schultern reichend; alle Glieder, mit Ausnahme des zweiten viel kürzeren, ungefähr von der gleichen Länge; Endglied ein wenig länger als das zehnte. Hals dick, Kragen breit.

Halsschild länger als der Kopf, aber deutlich schmaler als dieser. An den Seiten knapp vor der Basis schwach eingedrückt; Seiteneindruck lang, ziemlich scharf. Zerstreut, nicht grob punktiert; in der Mitte zuweilen feine Längsrinnen. Wie der Kopf behaart.

Flügeldecken ein und einhalb mal so lang als der Kopf mit dem Halsschilde. Basis fast gerade. Schulterecken kurz gerundet. An den Seiten um die Mitte deutlich breiter; Spitzen bogenartig abgestutzt. Ziemlich flach. Kein Posthumeraleindruck. Nahtstreifen kaum angedeutet. Sehr fein und sehr zerstreut punktiert und mit gelblichen nicht ganz anliegenden Haaren spärlich be kleidet; überdies wenige kurze, ganz abstehende Haare.

Beine sehr kräftig, Schenkel stark verdickt. *Das ♂ hat einfache Vorderschenkel und Vordertibien.*

Die Unterseite ist schwarz, lederartig, fein punktiert und teilweise chagriniert und mit kaum sichtbaren dunlken Härchen bedeckt. Das letzte vorstreckbare Tergit endet in *2 starke lederförmige, sehwarze, grob punktierte Lappen, die gewöhnlich vorstehen.* Das letzte sichtbare Sternit ist stark ausgebuchet und in der Mitte halbmondförmig ausgehöhlt.

3.6–4 Millimeter.

Mindanao: Mumungan (*Böttcher*).

Zur Gruppe *primitivus gehörig.*

FORMICOMUS DUBIUS sp. nov.

Dem *F. simulans* äusserlich ausserordentlich ähnlich, ja von diesem kaum unterscheidbar. Dennoch durch die abweichende Gestaltung der Endsegmente und namentlich dadurch typisch verschieden, dass die breiten lederförmigen Lappen des letzten vorstreckbaren Sternites fehlen und durch feinhäutige, leicht gedunkelte, stark behaarte Anhänge ersetzt sind. Auch das letzte sichtbare Sternit ist nicht ausgebuchtet und ausgehöhlt.

4 Millimeter.

Mindanao: Tangkulan.

FORMICOMUS CONFRATER sp. nov.

Ganz dunkelbraun, Kopf und Halsschild mit metallischen, Flügeldecken mit grünlichem Glanze.

Kopf kaum länger als breit, kreisrund, gewölbt; Augen mässig vorstehend. Kräftig, aber zerstreut punktiert; aus jedem Punkte entspringt ein feines gelbliches Haar; überdies wenige abstehnde Borstenhaare. Fühler lang, sehr kräftig, alle Glieder, bis auf das zweite viel kürzere, ungefähr von der gleichen Länge.

Halsschild etwas schmaler als der Kopf, doppelt so lang als breit, knapp vor dem Basalrande an den Seiten leicht eingedrückt. Seiteneindruck breit, nicht tief. Oberhalb des Basalrandes quer gerunzelt, sonst fein und zerstreut punktiert; wie der Kopf behaart.

Flügeldecken ein und ein halb mal so lang als Kopf mit dem Halsschilde; an den Seiten um die Mitte wenig breiter. Spitzen abgestutzt. Basis gerade. Schulterecken spitz. Schulterbeule angedeutet. Omoplaten nicht erhoben. Kein Nahtstreifen. Sehr fein und zerstreut punktiert und mit wenigen, nicht ganz anliegenden lichten Borstenhaaren spärlich bedeckt.

Beine lang, schlank; Schenkel sehr keulig. *Vorder schenkel und Vordertibien ♂ einfach.*

4.5 Millimeter.

Negros: Cuernos Mountains.

FORMICOMUS ABRUPTUS sp nov.

Mässig gross, schwarz, nur die ersten Fühlerglieder, die Tibien und Tarsen mit einem blutroten Stich; Flügeldecken leicht irisierend.

Kopf länglich-oval. Augen gross, vorstehend, leicht nach aufwärts gerichtet. Schläfen gleich hinter den Augen zur schmalen Basis convergierend. Hals kurz, vom Kopfe leicht abgesetzt. Crob und zerstreut punktiert und leich längsgeript. Mit kur-

zen abstehenden Haaren nicht dicht bedeckt. Fühler ziemlich lang, alle Glieder, bis auf das zweite viel kürzere, ungefähr von der gleichen Länge.

Halsschild schmaler als der Kopf, mehr als doppelt so lang als breit, vor der Basis schwach eingeschnürt. Seiteneindruck tief und breit. Vor der Basis querunzelig und mit einigen Längskerbungen, sonst fein und zerstreut punktiert und sehr schwach behaart.

Flügeldecken ein und ein halb mal so lang als der Kopf mit dem Halschilde, an den Seiten um die Mitte wenig breiter; Spitzen leitch abgestutzt. Basis fast gerade. Schulterecken spitz. Deutliche Schulterbeule. Kein Posthumeraleindruck. Nathstreifen kaum im letzten Drittel angedeutet. Sehr zerstreut und sehr fein punktiert; kaum behaart.

Beine lang, schlank; Schenkel mässig verdickt. *Vorderschenkel und Vordertibien des ♂ einfach.* Unterseite dunkelbraun, sehr glänzend; kaum punktiert und behaart.

4 Millimeter.

Insel Samar.

FORMICOMUS CONSPICIENDUS sp. nov.

Gross, schlank, ganz dunkelbraun bis schwarz, Flügeldecken mit grünlichem Schimmer.

Kopf länglich-elyptisch; Augen ziemlich gross und vorstehend. Schläfen lang. Clypeus mit schmal erhobenen Rändern. Dicht längsgekerbt, dazwischen grob punktiert. Unscheinbar behaart. Fühler kräftig und bis über die Schultern reichend (die Endglieder fehlen auf dem einzigen vorliegenden Exemplar).

Halsschild doppelt so lang als breit; Vorderlobus an den Seiten wenig erbreitet; mit Andeutung einer Mittelrinne. Seiteneindruck flach, darinnen dicht punktiert; sonst fein und zerstreut punktiert, daher glänzend; kaum behaart.

Flügeldecken mehr als doppelt so lang, als um die Mitte breit. Spitzen leicht abgestutzt. Basis zu den kurz gerundeten Schulterecken leicht abfallend; keine Schulterbeule; kein Posthumeraleindruck; Schildchen länglich-spitz. Sehr glänzend, kaum punktiert und behaart.

Beine kräftig. Schenkel sehr verdickt. Vorderschenkel des ♂ breitlappig in der inneren Mitte ausgezogen; Vordertibien des ♂ innen in der Mitte zahnartig erweitet. Unterseite dunkelrotbraun. sehr glänzend, *zwei spitze Fortsätze an der Basalmitte des ersten Sternites.*

4.7 Millimeter.

Manila.

Aehnliche Fortsätze am ersten order zweiten Sternit haben *F. consociatus* Kr. aus Mindanao, Mumungan, *F. appendicinus* Kr. aus Luzon, Montalban Gorge, und *F. longithorax* Kr. aus Los Baños.

FORMICOMUS LONGITHORAX Kr.

Formicomus longithorax KR., Philip. Journ. Sci. 27 (1925) 522.

Böttcher hat in Los Baños (VIII) einen *Formicomus* erbeutet, der das ♂ des von mir beschriebenen (♀) *F. longithorax* sein dürfte, obwohl er viel grösser (fast 8 Millimeter) ist.

Dieses ♂ ist dem *F. appendicinus* Kr. auch dadurch äusserst ähnlich, dass das erste Ventralsegment in der Mitte *zwei nach abwärts gerichtete, stark borstig behaarte und enger als beim F. appendicinus bei einanderstehende dornartige Fortsätze* aufweist.

FORMICOMUS PUMICATUS sp. nov.

Sehr glänzend. Kopf und Halsschild schwarz, Flügeldecken schwartz mit bronzegrünem Schimmer. Mundteile, Fühler und Beine dunkelrostrot.

Kopf länglich-oval. Augen gross, ziemlich vorstehend und leicht nach oben gerückt. Schläfen lang, gleich hinter den Augen mässig abnehmend. Basis kurz gerundet. Ueberall dicht längs-gerippt, dazwischen mit zerstreuten Ocellenpunkten, woraus feine, dunkle, abstehende Haare entspringen. Der Kopf ist überdies mit kurzen, dunklen, nicht anliegenden Haaren dicht bekleidet. Die Stirne ist nicht abgeflacht. Fühler schlank, die Schultern erreichend: alle Glieder, mit Ausnahme des kürzeren zweiten Gliedes, ungefähr von der gleichen Länge; Endglied kegelförgmig, spitz

Halsschild länger aber etwass schmaler als der Kopf, leicht gewölbt, kurz vor der schmalen Basis mässig eingeschnürt, Seiteneindruck breit und ziemlich tief. Stark und zerstreut punktiert, vor der Basis dicht gerunzelt. Mit feinen, nicht anliegenden, gelblichen Haaren ziemlich sparsam bedeckt.

Flügeldecken etwa ein und ein halb mal so lang als der Kopf mit dem Halsschilde. Basis gegen die kurz gerundeten Schulterecken leicht abfallend. An den Seiten um die Mitte mässig erbreitet, gegen die Spitzen deutlich verschmälert. Kein Posthumeraleindruck. Schulterbeulen deutlich. Mit zerstreuten Ocellenpunkten, dazwischen mit feinen Punkten nicht dicht bedeckt; aus den Ocellen entspringen gelbliche längliche, nicht anliegende Haare; dazwischen wenige ganz aufrechte Haare.

Schildchen länglich spitz. Nahtstreifen im letzten Drittel sehr schwach angedeutet.

Beine kräftig mit sehr verdickten Schenkeln. Vorderschenkel des ♂ mit einem starken zumeist abgestumpften Dorne an der Innenseite in der Mitte; die Vordertibien des ♂ sind distal hinter der Mitte innen leicht eingebuchtet. Alle Fusswurzeln heller braunrot. Unterseite glänzend, wiewohl etwas dichter punktiert; Sternite verworren, teilweise runzelig punktiert. Gelb, nicht anliegend nicht dicht behaart.

4.2–4.8 Millimeter.

Mindanao: Mumungan (*Böttcher*).

FORMICOMUS ROUYERI Pic.

Formicomus rouyeri PIC, Bull. Soc. Zool. de France (1914) 183.

Ich bringe die Zeichnung der Endsegmente auch dieses *Formicomus*, nach einem in Bataan Lamao (Luzon) erbeuteten, von Herrn Pic selbst determinierten Exemplare.

FORMICOMUS FOEDERATUS sp. nov.

Von der Grösse des *F. braminus*. Ganz rotbraun, nur die Flügeldecken schwarz mit grünem Glanze (Die Basis bleibt mehr oder weniger rotbraun) Tibien gebräunt. Glänzend. Schlank.

Kopf kaum länger als breit. Augen mässig gross und wenig vorstehend. Schläfen gleich hinter den Augen vermindert; Basis schmal gerundet. Dicht punktiert und längs-gerunzelt. Mit kurzen Borstenhaaren und einigen abstehenden feinen Haaren spärlich bekleidet. Fühler schlank, bis über die Schultern reichend; Endglied etwas länger als das zehnte, spitz.

Halsschild schmaler als der Kopf, fast doppelt so lang als um die Mitte breit. Seiteneindruck breit, nicht tief. Schwach und zerstreut, nur vor der Basis dichter punktiert. Mit feinen weissen, anliegenden und wenigen abstehenden Haaren bedeckt.

Flügeldecken doppelt so lang als um die Mitte breit. Basis zu den schmal gerundeten Schulterecken leicht abfallend. Kein Posthumeraleindruck. Schildchen länglichspitz, in der Mitte eingedrückt. Kein Nahtstreifen. Sehr fein und zerstreut punktiert und mit weisslichen anliegenden und abstehenden Haaren spärlich bekleidet.

Beine kräftig, Schenkel sehr verdickt. Vorderschenkel des ♂ an der Innenseite breit zu einem stumpfen Zahne ausgezogen; die stumpfe Kante ist mit kleinen Dornen versehen. Vordertibien des ♂ einfach.

4.2–4.5 Millimeter. Mindoro: San Teodoro (I) (*Böttcher*).

FORMICOMUS LEPIDUS sp. nov.

Klein, sehr glänzend; Kopf, Halsschild und Beine rötlichbraun (Kopf etwas dunkler); Fühler gelbbraun, die drei letzten Glieder verdickt und gedunkelt. Basis der Flügeldecken rötlichbraun; Flügeldecken sonst scharzbraun mit Ausnahme einer ziemlich breiten, zumeist an der Naht unterbrochenen und fast bis zum Seitenrande reichenden lichtgelben Binde.

Kopf kaum länger als breit; gleich hinter den grossen, vorstehenden Augen zum schmalen Basalrande vermindert. Zerstreut, eingestochen punktiert und mit gelblichen, teilweise abstehenden Haaren spärlich bekleidet.

Halsschild vorne stark erhoben; so breit als der Kopf bei den Augen. Sehr kräftiger, nach oben und aufwärts fortgesetzter Seiteneindruck. Basalrand schmal, lichter gelb. Fein und nur im Seiteneindrucke und vor der Basis etwas dichter punktiert und mit teilweise abstehenden Haaren spärlich bedeckt.

Flügeldecken weniger als ein und ein halb mal so lang als der Kopf mit dem Halsschild; an der Basis zu den ziemmlich breit gerundeten Schulterecken schräg abfallend; an den Seiten um die Mitte deutlich breiter; Spitzen gemeinsam gerundet. Schildchen länglich, spitz. Omoplaten leicht erhoben. Posthumeraleindruck deutlich. Ausserordentlich fein und zerstreut punktiert; aus den Punkten entspringen feine, gelbliche, fast anliegende Borstenhaare.

Vorderschenkel des ♂ geschwollen, mit einem langen Dorne an der Innenseite in der Mitte; Vordertibien des ♂ an der Unterseite ausgezogen und kantig abgesetzt. Unterseite rotbraun bis schwarzbraun, sehr glänzend, sehr fein punktiert und kaum behaart.

2.8–3 Millimeter.

Calapan (II) (*Böttcher*).

GRUPPE FORMICOMUS BRAMINUS LAFERTÉ

Eine ganze Reihe von asiatischen *Formicomus*, sowohl aus Vorder- als auch aus Hinter-Indien, aus Ceylon, China, Japan, dann auch aus dem malayischen Archipel figuriert in den verschiedentsten Sammlungen als *F. braminus* Laferté.[4] Genauere Untersuchungen ergaben so bedeutende Verschiedenheiten in dem Baue der Endsegmente dieser *Formicomus* verschiedener Heimat, das sich eine gründliche Revision als unumgmänglich notwendig erweist.

[4] Monographie (1848) 79.

Zu diesem Ende handelt es sich zunächst darum, festzustellen, *welcher Formicomus* als der *typische F. braminus* Laferté's anzusehen sei, ein Beginnen, dass um so schwieriger erscheint, als einerseits die Beschreibung Laferté's auf ein aus "Indien," ohne nähere Fundortbezeichnung stammendes Exemplar fusst, andererseits dem Autor 7 "indische" Exemplare in abweichenden Färbungen vorlagen; überdies erwähnt Laferté, dass sich unter den 7 Exemplaren nur ein einziges ♂ befand, dessen Abdomen keine Einbuchtung und dessen. Vorderschenken keinen Dorn aufwiesen. Offenbar hat Laferté überhaupt kein ♂ zu Gesicht bekommen, da unterschiedslos alle ♂ dieser und aller verwandten Arten bedornte Vorderschenkel aufweisen.

Unter den vielen Hunderten *F. braminus* (sensu lato), die mir untergekommen sind, passt am besten die Beschreibung Laferté's auf einen F. der Motschulsky'schen Sammlung in Moskau, dessen patria allerdings auch nur mit "India orientalis" angegeben ist. Es ist nicht unwahrscheinlich, dass Laferté und Motschulsky den *F. braminus* aus derselben Quelle hatten und so glaube ich, diesen *Formicomus* der Motschulky' schen Sammlung als den typischen *F. braminus* anspreshen zu dürfen. Zur Berkräftigung meiner Ansicht diene der weitere Umstand, dass ein aus den Ausbeuten Helfer's stammendes Exemplar aus Tenasserim eine conforme Gestaltung der Endsegmente aufweist. Laferté besass aber Anthiciden, die Helfer gesammelt hatte.

Ich bringe nun die Zeichnung der Endsegmente und des Penis des Exemplar's aus der Motschulky'schen Sammlung, welche, wie erwähnt mit denen eines Exemplar's aus Tenasserim identisch sind.[5] Hiemit ist ein fixer Ausgangspunkt gegeben, von welchem aus ich diese weit verbreitete Gruppe werde neu bearbeiten kömen. Ich beschränke mich im Rahmen der vorliegenden Studie diejenigen, dem *F. braminus* nahestehenden Arten zu beschreiben, welche bisher auf den Philippinen erbeutet worden sind.

FORMICOMUS PROTERVUS sp. nov.

Allgemeinfärbung braunrot bis blutrot, die Flügeldecken dunkler, eine schmale blutrote Quermakel unterhalb der Schultern freilassend. Glänzend.

[5] Die Gestaltung der Endsegmente der Formicomus-Arten ist oft so compliziert, dass die mikroskopischen Präparate namentlich alter Exemplare, je nach der Verschiedenheit der Lage der einzelnen Teile undeutliche und manchmal schwer zu erkennende Darstellugen bieten. In vielen Fällen bringe ich die einzelnen Teile der Endsegmente in verschiedenen Lagen, so auch hier. Die richtige Deutung kann nur durch Uebung erfolgen.

Kopf elyptisch-oval weniger länger als breit. Augen ziemlich gross und vorstehend; Schläfen länglich; Basis breitbogig. Zerstreut, occellenartig punktiert und mit gelblichen, teilweise ganz abstehenden Haaren nicht dicht bekleidet. Fühler lang, schlank, drittes bis elftes. Glied ungefähr von der gleichen Länge; Endglied spitz.

Halsschild weniger als ein und einhalb mal so lang als breit; vom Kragen schräg abfallend zur Mitte, wo der Halsschild die Breite des Kopfes hat; gegen die Basis abnehmend; Seiteneindruck breit und tief. Ziemlich gewölbt. Sehr zerstreut, teilweise grob punktiert und mit spärlichen Borstenhaaren spärlich bedeckt.

Flügeldecken ein und ein viertel mal so lang als der Kopf mit dem Halsschilde. Basis zu den spitzen Schulterecken leicht abfallend; an den Seiten um die Mitte mässig breiter. Posthumeraleindruck schwach angedeutet. Nahtstreifen äusserst schmal im lezten Drittel. Grob und zerstreut punktiert und mit gelblichen, nicht anliegenden, sowie mit einzelnen, ganz abstehenden Borstenhaaren sparsam bekleidet.

Beine, die Tibien inbegriffen, sehr kräftig und überall dicht gelblich behaart. Vorderschenkel des ♂ an der Unterseite in der Mitte zu einem breiten, etwas stumpfen Zahne ausgezogen; Vordertibien des ♂ gedunkelt und an der Unterseite in der Mitte leicht lappig erbreitet und von da bis zur Spitze mit kurzen Borstenhaaren und Dornen dicht bedeckt.

4 Millimeter.

Mindanao: Mumungan (*Böttcher*).

FORMICOMUS FRATERCULUS sp. nov.

Kopf und Halsschild rotbraun; Fühler und Beine dunkelrotbraun; Flügeldecken schwarzbraun mit gelblichroter, nicht bis zum Seitenrande reichender und auch an der Naht unterbrochener Posthuralblinde. Glänzend.

Kopf etwa so lang als bei den Augen breit. Diese gross und vorstehend. Hinter den Augen gleich zur kurzbogigen Basis vermindert. Ocellenartig, nicht dicht punktiert und mit lichten Haaren sparsam bedeckt. Fühler kräftig, zweites Glied sehr kurz; Endglied wenig länger als das zehnte.

Halsschild etwas länger als breit und so breit als der Kopf. An den Seiten vom Kragen aus bis knapp vor der Mitte schräg abfallend, dann ziemlich kräftig eingeschnürt. Leicht gewölbt. Seiteneindruck stark und breit. Wie der Kopf punktiert und behaart.

Flügeldecken um die Hälfte länger als der Kopf mit dem Halsschilde. Basis zu den ziemlich breit gerundeten Schulterecken leicht abfallend. Um die Mitte deutlich breiter; gegen die Spitze bogig sehr vermindert. Posthumeraleindruck kaum angedeutet. Mit groben zerstreuten und dazwischen mit feinen Punkten bedeckt und mit gelblichen längeren nicht anliegenden Haaren nicht dicht bekleidet.

Beine kräftig, alle Schenkel sehr verdickt. Vorderschenkel des ♂ an der Unterseite in der Mitte zu einem kräftigen Zahne ausgezogen; Vordertibien des ♂ distal leicht lappig verdickt und etwas geschwungen.

Unterseite rotbraun, glänzend, fein seicht punkiert und mit feinen gelblichen Haaren sparsam bekleidet.

3.8 Millimeter.

Mindanao: Kolambugan (II) (*Böttcher*).

FORMICOMUS AFFINIS sp. nov.

Grösser, sehr glänzend; Kopf und Halsschild gelbbraun, Flügeldecken schwarzbraun mit 2 kleinen rötlichen, undeutlich begrenzten Posthumeralmakeln. Beine dunkelbraun, die Wurzeln heller. (Fühler fehlen.)

Kopf etwas länger als breit. Augen sehr gross und sehr vorstehend. Schläfen länglich, Basis breitbogig. Vor den Fühlerwurzeln erhobene Leistchen, die sich vorne geradlinig vereinigen. Ocellenartig, zerstreut punktiert und mit gelblichen zum Teile abstehenden Harren sparsam bekleidet.

Halsschild gewölbt; um die Hälfte länger als breit, fast so breit als der Kopf. Seiteneindruck kräftig und breit. Grob nud zerstreut punktiert und wie der Kopf behaart. Flügeldecken mehr als ein und ein halb mal so lang als der Kopf mit dem Halsschilde. Basis zu den spitzen Schulterecken leicht abfallend. Um die Mitte deutlich breiter; Spitzen breitbogig vermindert. Ziemlich flach. Posthumeraleindruck angedeutet. Schildchen länglich, spitz. Nahtstreifen in der zweiten Hälfte deutlich, schmal. Sehr fein und sehr zerstreut punktiert und mit gelblichen, halb aufrechten Haaren nicht dicht bedeckt.

Beine sehr kräftig; Schenkel namentlich die vorderen sehr verdickt. Vorderschenkel des ♂ in der Mitte der Unterseite zu einem breiten abgestutzten Zahne ausgezogen; Vordertibien des ♂ in der distalen Mitte leicht lappig erweitert und vor der bedornten Spitze schwach eingebuchtet.

Unterseite rötlichbraun sehr glänzend; fein und zerstreut punktiert und licht, sparsam behaart.

4.8 Millimeter.

Mindanao: Surigao (XI) (*Böttcher*). Siargao (IX) (*Böttcher*).

Mit *F. castaneus* Kr. nahe verwandt.

FORMICOMUS TERMINATUS Pic.

Formicomus terminatus PIC, Echange (1895) 7, 9.

Da in den Sammlungen auch einige, als. *F. terminatus* determinierte Tiere vorkommen, so bringe ich die Zeichnung der Endsegmente eines F. aus Java (ohne nähere Ortsangabe), welchen Herr Pic selbst als sein *F. terminatus* bestimmte, und füge bei, dass mir ein F. mit gleichen oder ähnlichen Endsegmenten aus den Philippinen bisher nicht unterkam.

GRUPPE FORMICOMUS OBSCURUS PIC, OBSCURIOR PIC, RÖSELERI PIC

Es handelt sich hier um *Formicomus* Exemplare von der ungefähren Grösse unseres *F. pedestris* Rossi, von sehr veränderlicher Gestalt und Färbung, welche in den Sammlungen als *F. obscurus, obscurior,* und *röseleri* Pic bestimmt zu finden sind.

Der Durchsnittstypus ist durch folgende Merkmale ausgezeichnet: Allgemeinfärbung dunkelbraun bis schwarz, die Fühler etwas heller, ebenso die Beine; im ersten Drittel der Flügeldecken eine gelbe oder gelbrote Binde. Es kommen jedoch Formen vor mit geschwärzten Endgliedern der Fühler, mit geschwärzten Schenkeln und Tibien, endlich solche mit verminderter oder gänzlich fehlender heller Binde im ersten Drittel der Flügeldecken.

Ich habe bereits in meiner ersten Studie über die Anthiciden der Philippinen [6] auf die ausserordentliche Veränderlichkeit dieser *Formicomus* hingewiesen und die neuen Arten: *F. gratiosus* (3.6 Millimeter aus Basilan), *F. penangensis* (3 Millimeter aus Penang), *F. infuscatus* (3.5 Millimeter aus Tangkulan) und *F. iliganensis* (4 Millimeter aus Iligan) beschrieben.

Nun konnte ich neues sehr zahlreiches Material, namentlich aus den Böttcher'schen Ausbeuten genauer untersuchen und ich

[6] Philip. Journn. Sci. 27 (1925) 523.

[7] Loc. cit.

fand, dass die Endsegmente dieser äusserlich so sehr ähnlichen *Formicomus* so in die Augen springende Verschiedenheiten aufweissen, dass die Annahme gerechtfertigt sein dürfte, dass wir es hier möglicherweise auch mit Kreuzungen zu tun haben, wiewohl die bisherigen Untersuchungen und Erfahrungen *gegen* eine solche Annahme sprechen.

Jedenfalls fällt es schwer, gegenüber einer solchen Erscheinung Stellung zu nehmen, So sehr ich im Prinzipe der Schaffung neuer Arten ohne zwingende Notwendigkeit abhold bin, so kann ich dennoch angesichts der auffallenden Verschiedenheiten im Baue der Endsegmente nicht umhin, zur Aufstellung einer ganzen Raihe neuer Arten zu schreiten.

Es scheint mir aber wichtig, mich vorher noch mit jenen Arten zu beschäftigen, deren Namen den auf den Philippinen heimischen Arten häufig unzutreffenderweise gegeben worden ist. Am häufigsten finde ich solche *Formicomus* der Philippinen als *F. obscurus* und *obscurior* Pic bestiment.

Formicomus obcurus ist von M. Pic als ein auf Java sehr häufig vorkommende Art beschrieben worden [8] Die Beschreibung enthält keine besonderen, über die obige Summarbeschreibung des Durchschnittstypus hinausgehenden Merkmale, es wäre denn, dass die Augen grau und die Fühler kurz sind. Die Grösse wird mit 4-4.5 mm. angegeben. Der Autor sagt, dass *F. obscurus* dem ihm unbekannten *F. armatus* Bohem. nahesteht und erwähnt dass es Exemplare mit und solche ohne lichter Posthumeralbinde gibt.

Formicomus obscurior Pic wird als Varietät des *F. obscurus* von Herrn Pic folgendermassen beschrieben: "Eeytres depourvus de fascie antérierue rousse ou jaunâtre, et par consequence, à coloration uniforme d'un noir de poix ou brunâtre. Manila." [9]

Um nun den typischen *F. obscurus* aus Java genauer kennen zu lernen, habe ich mehrere Exemplare, die vom Autor selbst als *F. obscurus* diagnostiziert worden waren, untersucht. Ein solches Exemplar trägt keine genauere Fundortangabe, das zweite stammt aus dem Zuider-Gebirge (V), das dritte aus Tjilatjap (XII). Während bei allen diesen 3 Exemplaren das letzte sichtbare Sternit und der Penis ungefähr in der Gestalt übereinstimmen, weist die Gestalt der vorstülpbaren Endsegmente Verschiedenheiten auf, wie aus den Zeitchnungen zu ersehen, Dagegen zeigt ein viertes, von Herrn Pic gleichfalls als *F. obscurus*

[8] Le Natur (1894) 32.
[9] Ann. Soc. Ent. France (1902) 645.

determiniertes, aus Java (ohne näheren Fundort) stammendes Exemplar eine ganz abweichende Gestalt des sichtbaren Endsternites und der vorstülpbaren Endsegmente. Dieses letztere Tier gehört seinem Habitus nach eher zur *Braminus*-Gruppe.

Ich benutze diezen Anlass, um noch eines F. aus Banjoevangi (Java) zu gedenken, welcher von Herrn Pic einmal als *F. obscurus*, ein andermal als *F. javanus* (in litt.), determiniert wurde. Es handelt sich hier um eine neue Art mit charakteristischen Endsegmenten, welcher der Name *Formicomus javanus* Pic zu belassen wäre. Zu bemerken ist nur, dass dieser F. zwei feine Rippen am Unterrande der Mittelbrust hat.

Aus dieser Darstellung geht hervor, dass Java, gleichwie die Philippinen eine stattliche Anzahl von einander mehr oder minder differenzierten, in ihrem Aeusseren dem *F. obscurus* (sensu lato) ähnelnden Formen aufweist und ferner, dass der Bau der vorstülpbaren Endsegmente dieser javanischen F. von denjenigen der ähnlichen philippinischen F. zumeist abweichen.

Um zunächst die die javanischen F. betreffenden Fragen abzuschliessen, möchte ich alle F., deren Endsegmente die Formen 1-3 zeigen als *F. obscurus* vorläufig subsummiert belassen, teils weil mir genügendes Material mangelt, um zu erkennen, ob diese an sich variablen Formen sich irgendwie stabilisieren und wenn auch vielleicht die Aufstellung neuer Arten, so doch die Erkennung von Lokalrassen rechtfertigen, teils weil bei der Kompliziertheit der Endsegmente in der Darstellung möglicherweise Verzerrungen eintreten, die bei zahlreicheren Untersuchungsmaterial doch ein grössere Uebereinstimmung der Formen ergeben könnten.

Die zur Gruppe *F. obscurus* sensu lato gehörigen *Formicomus* der Philippinen sind die folgenden:

Formicomus röseleri PIC, Mitteil. Naturhist. Mus. Hamburg (1907) 178; KR., Philip. Journ. Sci. 27 (1925) 522, Taf. 3, fig. 10. 4–4.5 Millimeter. Luzon.

Formicomus gratiosus KR., Philip. Journ. Sci. 27 (1925) 523, Taf. 2, fig. 8. 3.6 Millimeter. Basilan.

Formicomus penangensis KR., Philip. Journ. Sci. 27 (1925) 524, Taf. 2, fig. 9. 3 Millimeter. Penang.

Formicomus infuscatus KR., Philip. Journ. Sci. 27 (1925) 524, Taf. 3, fig. 1. 3.5 Millimeter. Mindanao: Tangkulan.

Formicomus iliganensis KR., Philip. Journ. Sci. 27 (1925) 525, Taf. 3, fig. 2. 4 Millimeter. Mindanao: Iligan.

Ferner—

FORMICOMUS PLACIDUS sp. nov.

Posthumeralbinde breit, vollständig, rotgelb. Endglied der Fühler nicht länger als zehnte. Glied. Kopf und Halsschild grob und dicht punktiert, der Kopf auch teilweise gerunzelt, matter. Flügeldecken grob und zerstreut punktiert, glänzender Ueberall mit gelblichen, nicht anliegenden Borstenhaaren ziemlich dicht bekleidet. Vorderschenkel des ♂ mit wenig entwikkelter dorniger Anschwellung, Vordertibien (♂) leicht geschwungen und distal verdickt.

3.2 Millimeter.

Northern Palawan: Bacuit (XII).

FORMICOMUS IMPATIENS sp. nov.

Kopf, Halsschild und Beine dunkelrotbraun, Flügeldecken schwarzbraun mit einer schmalen, licht-rötlich-gelben, nicht bis zum Seitenrande reichenden und auch an der Naht schmal unterbrochenen Querbinde.

Halsschild und Flügeldecken glänzender als der Kopf, der gröber punktiert ist. Oberhalb der Augen Leistchen, die sich vorne vereinigen. Halsschild mit sehr starken Seiteneindrucke oberhalb des Basalrandes dicht und querrunzelig punktiert. Flügeldecken sehr zerstreut punktiert. Ueberall mit gelben nicht ganz anliegenden und wenigen ganz abstehenden Borstenhaaren bekleidet. Vorderschenkel des ♂ an der Unterseite in der Mitte zu eitnem etwas stumpfen Zahne stark ausgezogen; Vordertibien des ♂ distal geschwollen und knapp vor der gedornten Spitze deutlich abgesetzt.

Unterseite rotbraun, fein punktiert und mit sehr feinen Fransenhaaren siemlich reichlich bekleidet. Beim ♂ am unteren Rande der *Mittelbrust mit 2 abstehenden Rippen.*

3.4 Millimeter.

Negros: Dumaguete.

Lokalrasse: *F. impatiens-brunneus.* Kleiner an Gestalt, hellere braune Allgemeinfärbung. Die Posthumeralbinde verschwommener.

2.8 Millimeter.

Negros: Cuernos Mountains (*Baker*).

FORMICOMUS PACIFICUS sp. nov.

Oberkörper rotbraun, Flügeldecken etwas dunkler mit rötlichgelber, den Seitenrand nicht erreichender Posthumeralbinde. Kopf elyptisch, wenig länger als breit, Basis kurz. Glänzend. Kopf zerstreut, nur vorne etwas dichter, Halsschild an der Scheibe fein, gegen die Basis gröber, nicht dicht punktiert. Flü-

geldecken fein, wenig tief, zerstreut punktiert. Ueberall mit gelblichen abstehenden Borstenhaaren spärlich bedeckt. Vorderschenkel des ♂ mit starken, leicht abgestutzten Zahne; Vordertibien des ♂ einfach, an der Wurzel mit lichtem Haarbüschel.

3–3.2 Millimeter.

Northern Luzon: Ilnos.

FORMICOMUS OBFUSCATUS sp. nov.

Glänzend. Kopf, Halsschild, Fühler und Beine dunkelbraunrot, Flügeldecken schwarz, mit roter, den Seitenrand nicht erreichender und manchmal auch an der Naht unterbrochener, schmaler Posthumeralbinde. Kopf etwa so lang als breit. Fein und zerstreut, an der Stirne gröber und eingestochener punktiert; unscheinbar, wirr behaart.—Halschild länger als breit, etwas schmaler als der Kopf, an den Seiten vor der Basis kräftig eingeschnürt. An der Scheibe fein und ziemlich dicht, vor dem Basalrande quer runzelig punktiert; mit feinen lichten Hährchen dicht bekleidet. Flügeldecken an den Seiten um die Mitte mässig breiter. Basis zu den breit gerundeten Schulterecken leicht abfallend. Schildchen klein, dreieckig, punktiert. Omoplaten kaum erhoben. Posthumeraleindruck schwach angedeutet. Sehr zerstreut punktiert; aus jedem Punkte entspringt ein lichtgelbes, ganz oder halb aufrechtes längliches Borstenhaar. Beine kräftig, alle Schenkel stark verdickt. Vorderschenkel des ♂ zu einem starken, schmal abgestutzten zahne ausgezogen; Vordertibien des ♂ an der Unterseite vor der Spitze schwach geschwollen und sodann eingebuchtet.

3–3.5 Millimeter.

Zamboanga (XII) (*Böttcher*).

FORMICOMUS FUSCATUS sp. nov.

Schwarz, glänzend, dem *F. lucidus-coaequalis* Kr. sehr ähnlich, doch ist seine Behaarung weniger grob und etwas dichter. Auch beim *F. fuscatus* bilden die Haare eine Art Binde im seichten Posthumeraleindrucke. Seiteneindruck des Halsschildes breit; die Einschnürung des Halsschildes vor der Basis ist schwach und besteht eigentlich nur eine Verschmälerung des Halsschildes gegen die Basis zu. Der Dorn an der inneren Seite in der Mitte der Vorderschenkel des ♂ ist schwach ausgebildet.

3.4–3.6 Millimeter.

Luzon: Cabogao, Ripan.

FORMICOMUS TENELLULUS sp. nov.

Dem *F. fuscatus*, was die Gestaltung der Endsegmente anbelangt, sehr ähnlich, jedoch typisch verschieden.

Kleiner, schmächtiger, sehr glänzend; dunkelrotbraun, nur die Flügeldecken mit 2 gelblichen bindenartigen Makeln im Posthumeraleindrucke bei einem ♀; diese Makeln fehlen bei einem ♂, das übrigens eine viel dunklere Allgemeinfärbung aufweist, gänzlich; Tibien gedunkelt.—Ueberall sehr fein und sehr zerstreut punktiert und mit lichtgelben, zum Teile abstehenden kurzen Borstenhaaren sparsam bekleidet.—Vorderschenkel des ♂ zu einem spitzen Zahne ausgezogen; Vordertibien des ♂ leicht geschwungen, sonst einfach.

2.8 Millimeter.

N. Luzon: Kalinga, Lubuagan (3,000 Fuss I) (*Böttcher*).

FORMICOMUS ADULTUS sp. nov.

Grösser, schwarz, Kopf, Fühler und Schenkel mit einem rötlicehn Stich. Die Flügeldecken mit einer gelbbraunen schmalen, den Seitenrand nicht erreichenden Posthumeralbinde.—Kopf etwa so lang als breit, ziemlich gewölbt. Augen gross, vorstehend; Schläfen gleich hinter den Augen abnehmend zur breit gerundeten Basis Erhobene Leistchen vor den Fühlerwurzeln. Fein und sehr zerstreut, nur an der Stirne etwas dichter punktiert und mit kurzen, feinen, gelblichen Haaren spärlich bedeckt. Fühler kräftig, bis über die Schultern reichend, Endglied um die Hälfte länger als das zehnte.

Halschild länger als breit, fast sobreit als der Kopf; knapp vor der Basis kräftig eingeschnürt; Seiteneindruck breit, tief, stark nach vorwärts sich fortsetzend. Ziemlich grob, nicht tief und nicht dicht punktiert und spärlich mit feinen gelblichen Hährchen und überdies mit einzelnen ganz abstehenden Haaren be kleidet. Flügeldecken in der Mitte doppelt so breit als der Halsschild; etwa doppelt so lang als breit. Basis zu den spitzen Schulterecken deutlich abfallend. Posthumeraleindruck angedeutet. Schildchen länglich-spitz. Nathstreifen schmal. Sehr fein und sehr zerstreut punktiert und mit gelblichen nicht ganz anliegenden Borstenhaaren sparsam bedeckt. Beine ausserordentlich kräftig. Vorderschenkel des ♂ zu einem kräftigen, abgestutzten und an der abgestutzten Kante dicht gezahnten Dorne ausgezogen. Vordertibien des ♂ an der Unterseite in der distalen Mitte stark geschwollen. Unterseite hell gelbbraun, glänzend, kaum punktiert und behaart.

3.7 Millimeter.

Negros: Cuernos Mountains (*Baker*).

FORMICOMUS CRISPULUS sp. nov.

Dunkelbraun, Kopf und Halsschild gewöhnlich lichter rötlichbraun, ebenso Fühler und Beine und eine breite, fast das ganze

erste Drittel der Flügeldecken einnehmende, undeutlich begrenzte Querbinde. Kopf so breit als lang. Augen gross, mässig vorstehend; Schläfen zur breit gerundeten Basis leicht convergierend. Zerstreut und fein punktiert; aus jedem Punkte entspringt ein fast anliegendes gelbliches Borstenhaar. Fühler schlank, die Schultern erreichend; alle Glieder, bis auf das zweite kürzere, fast von der gleichen Länge, nur das Endglied um die Hälfte länger als das zehnte, spitz. Halsschild vorne etwas schmaler als der Kopf; länger als breit; an den Seiten hinter der Mitte schwach eingeschnürt; Seiteneindruck nicht tief. Wie der Kopf punktiert und behaart. Flügeldecken doppelt so lang, als um die Mitte breit. Basis gerade; Schulterecken spitz; Posthumeraleindruck gerade, seicht; sehr fein und sehr zerstreut punktiert; aus jedem Punkte entspringt ein halb aufrechtes lichtgelbes Borstenhaar. Beine kräftig; Schenkel verdickt. Vorderschenkel des ♂ in der Mitte der Innenseite zu einem kräftigen spitzen zahne ausgezogen; Vordertibien des ♂ einfach.

3 Millimeter.

Mindoro: Mangarin (XI) (*Böttcher*).

FORMICOMUS PHILIPPINENSIS Pic.

Formicomus philippinensis PIC, Mél. exot. ent. fasc. 4 (1912) 11; KR., Philip. Journ. Sci. 27 (1925) 527.

Auch von Böttcher in Mengen in Iligan (V) erbeutet. Alle diese Exemplare weisen eine mehr oder minder vollständige rotgelbe Posthumeralbinde auf.

Ich bringe nochmals die Zeichnung der Endsegmente, auch aus dem Grunde, weil das sichtbare Endsternit in der Mitte einen behaarten Fortsatz hat, der bei dem ersten untersuchten Exemplare fehlte.

FORMICOMUS LUCIDUS Kr.

Formicomus lucidus KR., Philip. Journ. Sci. 27 (1925) 527, Taf. 3, fig. 6.

Eine weit verbreitete Art, die zahlreiche Lokalrassen aufweist. Ich bringe eine neue deutlichere Zeichnung der Endsegmente. Rassen:

Formicomus lucidus-coaequalis.

Von constanter auffallend kleinerer Gestalt und fast ganz schwarz gefärbt; es kommen aber auch Exemplare vor, deren Vorderkörper und deren Beine elnen dunkelroten Stich haben und einige weisen zwei undeutliche kleine rote Posthumeralmakeln auf. Die aus weissen Borstenhaaren bestehende Bahaarung tritt deutlicher hervor nud bildet in dem ziemlich ausgeprägten

Posthumeraleindruck eine Art Binde. Die nicht dichte Behaarung ist abstehend.

2.8 Millimeters.

Luzon: Mount Maquiling.

Mr. Baker hat an dem gleichen Fundorte auch echte *F. lucidus* erbeutet. Es lassen sich übrigens Uebergänge zwischen der typischen Form und der Lokalrasse feststellen.

Formicomus lucidus-pullatus.

Allgemeinfärbung schwarz, Kopf und Halsschild mit rotbraunen Stich; zwei undeutlich begrenzte rundliche Flecken an Stelle der rötlichgelben Posthumeralbinde. Glänzend. Ueberall sehr schwach und sehr zerstreut punktiert; nur an der Scheibe des Halsschildes oberhalb des Basalrandes etwas dichter; mit gelblichen, nicht anliegenden Borstenhaaren sparsam bekleidet. Endglied der Fühler um die Hälfte länger als das zehnte, sehr spitz. Vorderschenkel des ♂ in der Mitte an der Unterseite ausgezogen und in einen leicht abgestutzten Dorn endigend; Vordertibien des ♂ einfach.

3.2 Millimeter.

San Miguel (III), Pagsanjan (III) (*Böttcher*).

Formicomus lucidus-basinotatus.

Halsschild und Beine heller rotbraun. Postmedianbinde heller und breiter une dimmt fast das ganze erste Drittel der Flügeldekken ein.

3.1 Millimeter.

Northern Palawan: Binaluan (I). Masbate (VIII) (*Böttcher*).

Formicomus lucidus-assimilis.

Grössere Gestalt. Vordertibien des ♂ mehr geschwollen. Beim letzten sichtbaren Endsternit fehlt das Mittelzäpfchen.

3.5 Millimeter.

Catanduanes: Virac (III) (*Böttcher*).

FORMICOMUS PRAETOR Laf.

Formicomus präetor LAF., Monographie (1848) 92.

Auf den Philippinen kommt dieser ostindische *Formicomus* auch vor, jedoch ist die Färbung des Kopfes und des Halsschildes, sowie des ersten Drittels der Flügeldecken nicht rötlich, sondern constant schwarz und weisen höchstens einige Exemplare einen blutroten Stich an diesen Körperteilen auf. Ausser der aus weissen Haaren gebildeten Posthumeralbinde, ist auch die sonstige

(spärliche) Behaarung weiss. Die Endsegmente der philippinischen Tiere sind etwas verscheden von jenen der ostindischen typischen Form. Ich erblicke in den Philippinischen Tieren eine Lokalrasse die ich.

Formicomus praetor-promiscuus benenne.

2.7 Millimeter.

Manila (XI) (*Böttcher*), Montalban (III) (*Böttcher*). Negros: Dumaguete.

ANTHLEPHILUS INHUMERALIS Pic.

Anthlephilus inhumeralis PIC, Annal. Soc. ent. France 71 1902 (1903) 644.

Neue Fundorte: Luzon: Manila; Mount Banahao (IV); Montalban (III). N. Luzon: Kalinga, Lubuagan (3,500 Fuss I). Mindoro: Mangarin (XI).

TOMODERUS

TOMODERUS PROMISCUUS sp. nov.

Klein, sehr glänzend; Kopf und Halsschild gelbbraun (die Einschnürung des Halsschildes dunkler); Flügeldecken rötlichbraun, bei den Omoplaten und hinter der Mitte undeutlich gedunkelt; Fühler und Beine hellgelb.

Kopf quer. Augen gross, vorstehend; Schläfen sehr kurz. Fein und zerstreut punktiert. Mit lichten abstehenden Haaren spärlich bedeckt. Fühler kurz, drittes Glied länger als das vierte bis zehnte; sechtes bis zehntes Glied breiter und sehr quer; Endglied mehr als doppelt so lang als das zehnte, spitz; alle Glieder dicht licht behaart.

Halsschild um die Hälfte länger als der Kopf. Vorderlobus schmaler als der Kopf. Einschnürung breit und kräftig; Hinterlobus noch schmaler als der Vorderlobus. Schwach und zerstreut, nur in der Einschnürung dichter und gröber punktiert; mit abstehenden lichtgelben Haaren spärlich bedeckt.

Flügeldecken fast doppelt so lang als der Kopf mit dem Halsschilde, an der geraden Basis doppelt so breit als der Hinterlobus des Halsschildes. Schulterecken breit gerundet. Omoplaten mässig erhoben. Posthumeraleindruck angedeutet, Nahtstreifen in der zweiten Hälfte deutlich, breit. Dicht und ziemlich stark punktiert und mit weisslichen nicht anliegenden Haaren ziemlich dicht bekleidet. Beine schlank.

2 Millimeter.

Mindanao: Surigao (XI) (*Böttcher*).

TOMODERUS LONGITHORAX sp. nov.

Grösser, sehr glänzend, ganz dunkelrotbraun, nur die Fühler- namentlich deren Endglieder- lichter gelbraun; auch die Beine etwas lichter.

Kopf quer leicht gewölbt. Augen klein, kaum vorstehend; Schläfen etwas länger und leicht convergierend zur geraden Basis. Fein und zerstreut punktiert und unscheinbar licht behaart. Fühler schlank, die Schultern erreichend, siebentes bis zehntes Glied quer; Endglied doppelt so lang als das zehnte spitz. Alle Glieder kräftig und ziemlich dicht behaart.

Halsschild fast doppelt so lang als der Kopf. Vorderlobus schmaler als der Kopf. Einschnürung kräftig, breit. Hinterlobus kurz, schmaler als der Vorderlobus. *In der Einschnürung mit einer deutlichen Mittelrinne.* Ausserordentlich fein und zerstreut punktiert; kaum behaart.

Flügeldecken ziemlich eiförmig, gewölbt; um die Hälfte länger als der Kopf mit dem Halsschilde. Basis zu den breit gerundeten Schulterecken leicht abfallend. Keine Schulterbeule. Kein Posthumeraleindruck. Nicht grob, ziemlich dicht, leicht gereiht punktiert; mit feinen lichtgelben Haaren dicht bedeckt. Beine ziemlich kräftig.

2.4 Millimeter.

Northern Luzon: Ilnos Mountains.

TOMODERUS RECONDITUS sp. nov.

Schlanker als die vorstehenden Arten mit *ganz fehlenden Schultern* (daher *ohne Unterflügel*); ganz rotbraun, die Fühler und die Beine hellgelb.

Kopf eiförmig, leicht gewölbt, glänzend. Augen klein; Schläfen länglich und zur geraden Basis bogig abnehmend. Fein und zerstreut punktiert und mit lichten, teiweise abstehenden Haaren spärlich bedeckt. Fühler sehr kräftig, bis zur Basis des Halsschildes reichend, alle Glieder mit weisslichen abstehenden Haaren dicht bekleidet; fünftes bis zehntes Glied breiter quer; Endglied um die Hälfte länger als das 10., nicht sehr spitz.

Halsschild um die Hälfte länger als der Kopf. Vorderlobus etwa so breit als der Kopf. Einschnürung mässig; Hinterlobus wenig schmaler als der Vorderlobus. Der vordere Teil fast unpunktiert, glänzend; die Einschnürung und der hintere Teil dichter und gröber punktiert, matter; mit zum Teile sehr langen, lichten, abstehenden Borstenhaaren nicht dicht bekleidet.

Flügeldecken eiförmig, leicht gewölbt. Kein Posthumeraleindruck. Nahtstreifen fast vollständig, erhöht. Ziemlich grob, nicht dicht punktiert und mit gelblichen, nicht anliegenden

Haaren reichlich bedeckt. Beine mässig kräftig; Schenkel leicht verdickt.

2.4 Millimeter.

N. Luzon: Nueva Vizcaya, Imugan (V) (*Böttcher*).

TOMODERUS PULLATUS sp. nov.

Klein, glänzend, schmutzigbraun, Fühler und Beine heller.

Kopf quer; Augen klein, mässig vorstehend; fein und zerstreut punktiert und mit weisslichen Haaren schwach bedeckt. Fühler schlank, die Basis der Flügeldecken erreichend; Glieder acht bis zehn quer; Endglied mehr als doppelt so lang als das zehnte, spitz.

Halsschild kaum ein und ein halb mal so lang als der Kopf; vorne faste so breit als der Kopf, hinten schmaler. Einschnürung tief und kurz. *Mit einem feinen tiefen Längseindrucke,* der vor dem Basalrande aufhört. Sehr zerstreut punktiert und schwach behaart.

Flügeldecken fast doppelt so lang als der Kopf mit dem Halsschilde. Basis leicht abfallend zu den ziemlich breit gerundeten Schulterecken. Omoplaten nicht erhoben. Kein Posthumeraleindruck. Nahtstreifen ziemlich breit, erhoben. Grob und dicht punktiert und mit feinen gelblichen Haaren spärlich bekleidet. Beine kräftig, Schenkel ziemlich verdickt, Mittel- und Hintertarsen lang.

1.9 Millimeter.

Luzon: Mount Maquiling.

ANTHICOMORPHUS

ANTHICOMORPHUS RUFUS Kr.

Anthicomorphus rufus KR., Philip. Journ. Sci. 27 (1925) 531, Taf. 1, fig. 8.

Neuer Fundort: Insel Samar (*Baker*).

ANTHICOMORPHUS ATRONOTATUS Pic.

Anthicomorphus atronotatus PIC, Mél. exot. ent. **36** (1922) 18.

Es liegen mir ein ♂ und ein ♀, die Böttcher in Los Baños (IV) erbeutete, vor, auf welche Exemplare die Beschreibung Pic's gut passt. Die Flügeldecken sind im ersten Drittel und um die Mitte, hier bindenartig, gedunkelt. Die Fühler des ♂ sind kurz, das dritte bis zum zehnten. Gliede quer, das Endglied fast viermal mal so lang als das zehnte. Beim ♀ ist das Endglied der Fühler kürzer und spitzer.

ANTHICOMORPHUS BICOLORATUS sp. nov.

♀. Kopf, Halsschild und Beine rot, Flügeldecken bläulichschwarz, nur an der Basis gerötet. Fühlerglieder drei bis zehn und alle Tibien leicht gedunkelt.

Kopf leicht quer-elyptisch, ziemlich gewölbt; Basis breit gerundet; Augen gross, rund, vorstehend, leicht nach oben gerückt. Dicht und stark punktiert; mit sehr feinen, gelblichen, darunter auch einigen abstehenden Haaren bedeckt. Fühler lang, schlank, leicht gesägt; erstes Glied breit; sechstes bis zehntes Glied etwa, so lang als breit; Endglied fast doppelt so lang, als das zehnte spitz.

Halsschild etwas schmaler als der Kopf, und um die Hälfte länger als breit. Seiteneindruck breit, kräftig. Wie der Kopf punktiert und behaart.

Flügeldecken fast parallel, etwas mehr als doppelt so lang als breit. Basis gerade. Schulterecken kurz gerundet. Schulterbeule deutlich. Omoplaten erhoben. Posthumeraleindruck breit, gerade. Fein, regelmässig, nicht sehr dicht punktiert; mit gelblichen, leicht abfallenden Härchen ziemlich dicht bekleidet.

Beine schlank; Schenkel wenig verdickt. Unterseite rot.

3.5 Millimeter.

Basilan (*Baker*).

ANTHICOMORPHUS HIRTULUS sp. nov.

Ganz dunkelrotbraun, ziemlich glänzend.

Eine durch die sehr langen und sehr schlanken nicht gesägten Fühler, deren Endglied doppelt do lang, ist, als die vorletzten Glieder, sowie durch die runden, besonders stark vorstehenden Augen (die auch beim ♂ weit von einander stehen) ausgezeichnete Art. Kopf und Halsschild dicht, fein und tief, die Flügeldecken weniger dicht und tief punktiert. Die Flügeldecken mit feinen gelblichen nicht ganz anliegenden Haaren dicht, und überdies mit ebenso gelblichen, aber längeren und ganz abstehenden Haaren spärlich bekleidet. Omoplaten deutlich erhoben. Posthumeraleindruck sehr kräftig.

3.5 Millimeter.

Samar (*Baker*). Bulusan (*Böttcher*).

PSEUDOLEPTALEUS

PSEUDOLEPTALEUS BIFIDUS sp. nov.

Klein, sehr glänzend; Allgemeinfärbung dunkelbraun, die Fühlerglieder eins bis acht, die Tibien distal sowie die Tarsen hellrotbraun, die Posthumeralbinde rötlichgelb.

Kopf etwas breiter als lang, quer-elyptisch, gewölbt. Augen fast rund, vorstehend. Zerstreut, fein, aber tief punktiert und mit sehr feinen, teilweise abstehenden Haaren spärlich bedeckt; Fühler schlank, die Schultern erreichend; das neunte und

zehnte Glied quer, Endglied um die Hälfte länger als das zehnte, Alle Glieder licht, fein behaart.

Halsschild schmaler und um die Hälfte länger als der Kopf. Vorderlobus im ersten Drittel am breitesten, dann gegen die Einschnürung geradlienig abnehmend, stark erhoben; Hinterlobus schmaler und kurz, mit zwei kleinen Erhebungen vor dem Basalrande; zwischen letzterem und den zwei Erhebungen eine kurze eingedrückte Längslinie. Seiteneindruck breit und tief, mit zwei Reihen anliegender feiner Haare. Zerstreut und ziemlich grob punktiert und mit feinen gelblichen Haaren regelmässig und ziemlich dicht bekleidet.

Flügeldecken an der geraden Basis so breit als der Vorderlobus des Halsschildes; an den Seiten um die Mitte deutlich breiter, zu den gemeinsam gerundeten Spitzen stark verengt. Schultterecken spitz. Posthumeraleindruck deutlich. Schildchen klein, halbrund. Nahstreifen im letzten Drittel sichtbar, seitlich leicht eingedrückt. Wie der Halsschild punktiert und behaart. Die Haare stehen im ersten Drittel in der Mitte nach rechts und links gescheitelt.

Beine schlank, Schenkel leicht verdickt.

Unterseite lichtbraun. Hinterbrust grob und zerstreut, Sternite fein und dicht punktiert und dicht behaart.

2–2.2 Millimeter.

Mindanao: Tangkulan, Mumungan: Iligan (II) (*Böttcher*). Negros: Cuernos Mountains.

PSEUDOLEPTALEUS CAPILLATUS sp. nov.

Ganz dunkel-bis schwarz-braun, nur die Fühler und die Beine gelbrot (die Schenkel manchmal leicht gedunkelt) ; auf den Flügeldecken eine gelbe Posthumeralbinde und unterhalb der Mitte je eine bindenartige, gegen die Naht nach vorwärts gerichtete, die Naht selbst nicht erreichende gelbe Makel. Die gelben Binden sind mit einer silberhaarigen dichten Behaarung bedeckt; die vordere Behaarung steht gescheitelt (Die Zeichnung ähnelt sehr derjenigen unseres *Anthicus transversalis* Villa= *tenellus* Lafterté.).

Kopf langgestreckt und an den Seiten parallel. Die mässig vorstehenden Augen sehr nach vorne gerückt; Schläfen lang. Basis spitzbogig. Grob und sehr dicht, ineinanderfliessend punktiert. Mit sehr feinen weisslichen Haaren oberflächlich behaart. Fühler schlank, nicht bis zu den Schultern reichend, zweites Glied kaum kürzer als das dritte; neuntes und zehntes. Glied leicht quer; Endglied um die Hälfte länger als das zehnte, spitz.

Halsschild breiter als der Kopf und wenig länger als dieser; um die Mitte stark eingeschnürt und zur Basis gerade abfallend. Seiteneindruck sehr breit und tief. Wie der Kopf behaart und punktiert jedoch dichter und silberiger behaart.

Flügeldecken kaum um die Hälfte länger als der Kopf mit dem Halsschilde. Basis sehr gerade, Schulterecken ziemlich spitz; an den Seiten um die Mitte mässig breiter. Ziemlich flach mit seichtem Posthumeraleinducke. Weniger grob und dicht punktiert als am Vorderkörper; dicht doppelt färbig behaart.

Beine schlank, Schenkel mässig verdickt.

2.8–3 Millimeter.

Manila (III) (*Böttcher*).

ANTHICUS

ANTHICUS SINUATIPES Pic.

Anthicus sinuatipes PIC, Annat. Mus Genova 20 (1899–01) 799.

Dieser, von Herrn M. Pic aus den Mentawei'Inseln beschriebene *Anthicus* wurde von Böttcher in Bulusan (X), in Surigao (IX) und in Dapa, Siargao (IX) erbeutet.

Ich bringe die Zeichnung dieser durch den besonderen Bau der Hintertibien des ♂ ausgezeichneten Art.

ANTHICUS MEDIONOTATUS Pic.

Anthicus medionotatus PIC, Le Natur. (1903) 56.

Es liegen mir drei Anthicus aus Manila (X) vor, auf welche die Beschreibung Pic's im Allgemeinen passt; jedoch haben alle diese drei Exemplare ausser der dunklen Medianbinde noch eine dunkle Anteapicalmakel.

Ich bringe auch die Zeichnung dieser Art.

ANTHICUS HIRTISETOSUS Mars.

Anthicus hirtisetosus MARS., Notes Leyd. Mus. (1884) 164.

Neue Fundorte dieser weit verbreiteten Art: Surigao; Binaluan (Northern Palawan, XI, XII, *Böttcher*). Negros: Cuernos Mountains (*Baker*).

ANTHCUS CRINITUS Laf.

Anthicus crinitus LAFERTÉ, Monographie (1848) 204.
Anthicus manilanus PIC, Ann. Soc. Ent. France (1902) 646.

Anthicus manilanus Pic ist, wie ich durch genaue Untersuchung, auch des Kopulationsorganes feststellte, synonim mit *A. crinitus* Laf. Böttcher erbeutete diesen *Anthicus* in Manila (III).

ANTHICUS PUMICATUS sp. nov.

Glänzend. Kopf und Halsschild fast schwarz, Flügeldecken rötlichbraun, die Basis schmal schwarz gesäumt; im letzten Drittel mit einer ziemlich breiten, den Seitenrand nicht erreichenden, schwarzen Quermakel. Fühler und Beine gelbbraun, die ersteren distal leicht gedunkelt; ebenso die Tibienwurzeln.

Kopf länglich-elyptish, ziemlich flach. Augen sehr gross und sehr vorstehend. Grob und zerstreut punktiert und mit kurzen abstehenden Borstenhaaren nicht dicht bekleidet. Fühler schlank, bis über die Schultern reichend; achtes bis zehntes Glied etwas verdickt und leicht quer, Endglied etwas länger als das zehnte, spitz.

Halsschild wenig länger als der Kopf, am Vorderlobus schmaler als dieser, an den Seiten um die Mitte scharf eingeschnürt; Hinterlobus noch schmaler als der Vorderlobus. Fein und namentlich in der Einschnürung dicht punktiert. Ebenso wie der Kopf, nur noch spärlicher behaart.

Flügeldecken ein und einhalb mal so lang als der Kopf mit dem Halsschilde. Basis sehr gerade. Schulterecken ziemlich spitz. An den Seiten hinter der Mitte mässig breiter. Eher flach. Schulterbeule deutlich. Posthumeraleindruck angedeutet. Sehr grob und sehr zerstreut, etwas reihenförmig punktiert und mit länglichen abstehenden, lichten Haaren ziemlich dicht bekleidet.

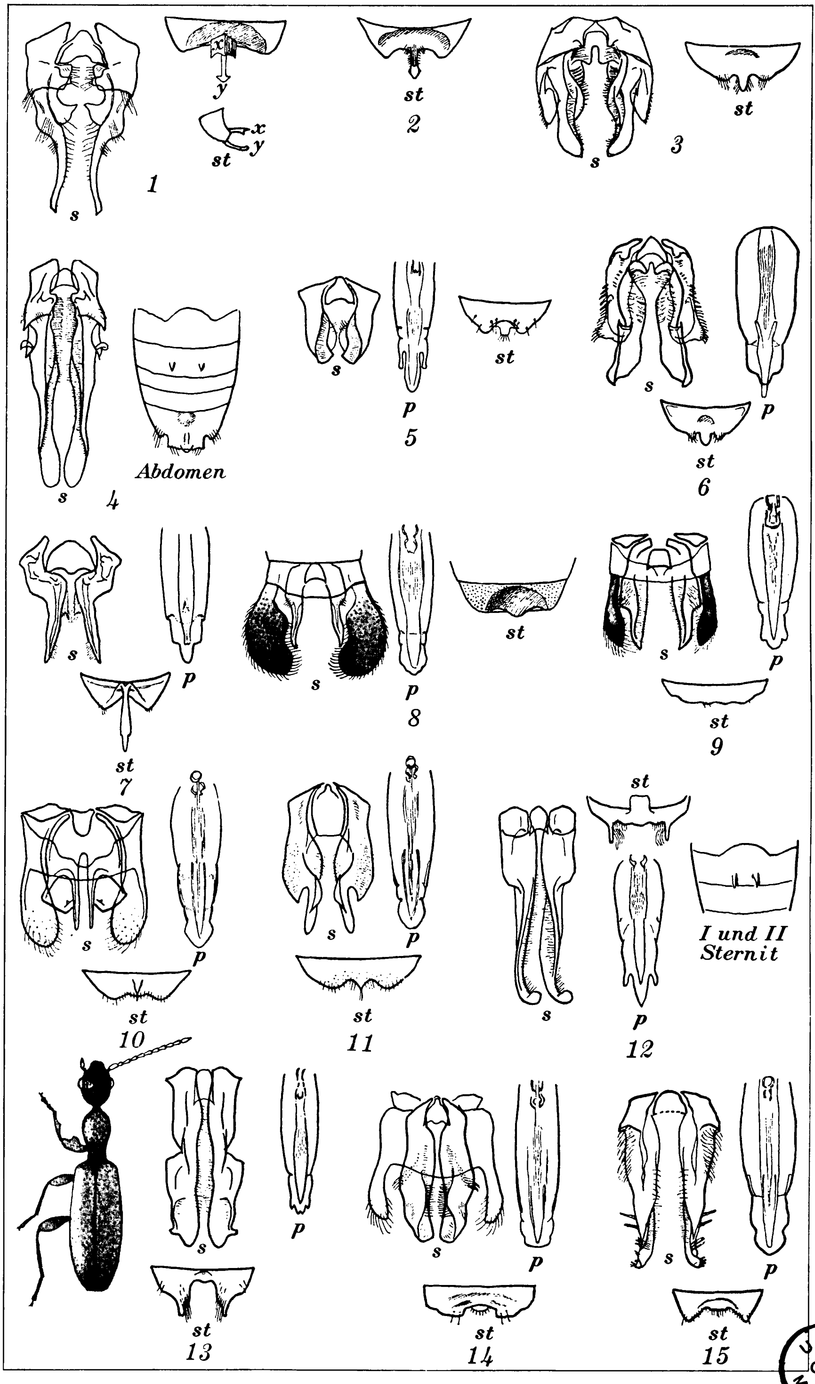
Beine schlank, Schenkel wenig verdickt. Unterseit dunkelrotbraun, zerstreut punktiert und mit gelblichen, fast anliegenden Haaren sparsam bedeckt.

2.7 Millimeter.

Mount Maquiling (*Baker*).

Auf den ersten Blick einem *Pseudoleptaleus* ähnlich. Doch glaube ich diesen *Anthicus* eher in die Gruppe X *Clavicomus* (Clavicolles Marseul's) einreihen zu sollen.

ILLUSTRATIONEN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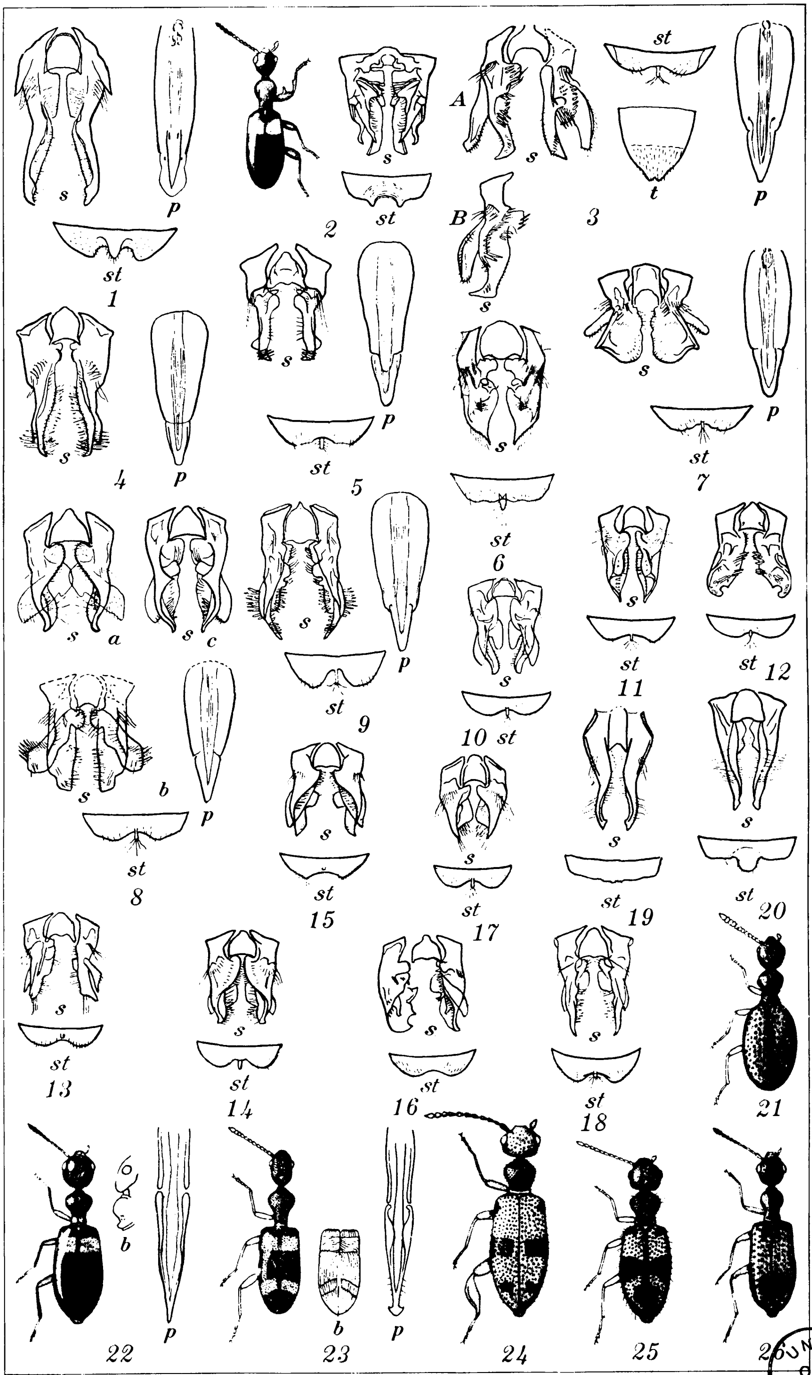
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TAFEL 2.

RESINS IN THE SEED COATS OF PHILIPPINE CHAULMOOGRA SEEDS (HYDNOCARPUS ALCALÆ)

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ONE PLATE

The ethyl ester of chaulmoogric acid has been used in the treatment of leprosy. Chaulmoogric acid occurs in chaulmoogra, hydnocarpus, and lukrabo oils. The official chaulmoogra oil is obtained from the seeds of *Taraktogenos kurzii* King which is a tree indigenous to Burmah and Assam. The Philippine oil from *Hydnocarpus alcalæ* (Plate 1) contains a larger percentage of chaulmoogric acid than any of the other oils of the chaulmoogra group. The Philippine oil is obtained from seeds known locally as dudu-dudu.

The ordinary method of preparing Philippine chaulmoogra oil consists of removing the thin shells from the seeds, grinding the kernels, and extracting the pulp with ether, though the pulp could, of course, be hot pressed. As the kernels are covered with a dark skin, or seed coat (tegmen), the oil thus prepared has a yellow to a light brown color. Some experiments which we have carried out recently showed that if the brown seed coat (tegmen) is first removed from the kernels before extracting with ether the oil obtained is a white solid fat.

We thought it might perhaps be interesting to obtain some data on this white solid fat prepared from the Philippine seeds of *Hydnocarpus alcalæ* and also on the brown seed coat (tegmen) which was removed from the kernels of these seeds. Our results show that the white fat contains no resin acids while the seed coat contains 3.73 per cent of resin acids. Oil extracted from the seed coat also gave figures for the iodine number, free fatty acids, and unsaponifiable matter, which were slightly higher than the corresponding data obtained for the white fat. According to our experiments the resin acids of *Hydnocarpus alcalæ* seeds appear to be contained in the brown seed coat (tegmen) of the kernel and not in the kernel itself. If the seed coat is removed from the kernels before preparing the oil then the oil appears

to be free of resin acids and also of most of the yellow coloring matter contained in the seed coat.

Power,[1] who first worked out the formula for chaulmoogric acid, found that the true chaulmoogra oil (*Taraktogenos kurzii* King) contained resins. He had some difficulty in separating his pure compounds from these resins.

All the samples of Philippine chaulmoogra oil (*Hydnocarpus alcalæ*) which we have examined contained resins. Crude chaulmoogric acid separated from this oil contained small quantities of resin acids. Our usual method for separating chaulmoogric acid from the resin acids consists in treating the mixture with gasoline or petroleum ether which dissolve only the chaulmoogric acid.[2]

When used in the treatment of leprosy chaulmoogra oils sometimes have an irritating effect on the patient. This may be due to the resins contained in these oils.

The fruit of *Hydnocarpus alcalæ* is large and somewhat oval in shape, resembling to some extent a small unhusked coconut. It is about 20 centimeters in length and about 15 centimeters in width. Within the pericarp the seeds are embedded in the pulp and arranged in a rather circular manner. The seeds measure about 3 centimeters in length.

The Philippine oil (*Hydnocarpus alcalæ*) of the chaulmoogra oil group has been investigated by Brill [3] and also by Perkins and Cruz.[4] According to Brill the dried seeds of *Hydnocarpus alcalæ* contain 65.50 per cent of oil and the oil yields about 90 per cent of chaulmoogric acid. Since the acid content of this oil is unusually high it naturally serves as a good source of material for the preparation of chaulmoogric acid and its derivatives and also chaulmoogryl substituted compounds.[5]

EXPERIMENTAL PROCEDURE

The seeds of *Hydnocarpus alcalæ* used in this investigation were kindly presented to us by Dr. Nemesio Mendiola, of the

[1] Power, F. B., and F. H. Gornall, Journ. Chem. Soc. Trans. **85** 1 (1904) 838.

[2] Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 266.

[3] Philip. Journ. Sci. **12** (1917) 37.

[4] Philip. Journ. Sci. **23** (1923) 543.

[5] Herrera-Batteke, P. P., and A. P. West, Philip. Journ. Sci. **31** (1926) 161; Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265, **35** (1928) 405; Santos, I. de, and A. P. West, Philip. Journ. Sci. **38** (1929) 293, **38** (1929) 445.

College of Agriculture, University of the Philippines. The thin shells were first removed from the seeds. The brown seed coat (tegmen) was very carefully removed in thin sections from the kernels by paring with a knife. The kernels were then ground to a pulp and extracted twice with ether. Each extraction lasted about two hours. The ethereal extract had a slight cream color due, perhaps, to the fact that all the seed coat was not entirely removed from the seeds. The warm extract was decolorized by treating with about 2 per cent of vegetable charcoal (suchar). Most of the suchar was then removed by filtering. In order to remove the last traces of suchar the warm ether extract was treated with about 1 per cent of talcum powder and filtered. The extract was then dehydrated with anhydrous sodium sulphate, filtered, and distilled to eliminate most of the ether. When the residue was evaporated a white solid fat was obtained. This was tested for oil constants such as saponification and iodine values and also for resin acids.

The brown seed coat (tegmen) which was removed from the seeds was ground to a pulp and heated (reflux) for about two hours with alcoholic potassium hydroxide. The mixture was filtered to eliminate the vegetable fiber. The clear solution was then acidified with dilute sulphuric acid and extracted with ether. The ether extract was dehydrated with sodium sulphate, filtered, and distilled to eliminate the ether. The last traces of ether were removed by placing the residue in an evaporating dish before an electric fan. The residue was then treated with petroleum ether and allowed to stand overnight. The petroleum ether precipitated the resin acids and dissolved the nonresinous material. Usually a portion of the resin acids adheres to the sides of the flask and is difficult to remove. The mixture was filtered and the filter paper returned to the flask in which the acids were precipitated. The resin acids were then dissolved in ether. The ethereal solution was dehydrated with sodium sulphate, filtered into a weighed flask, and the ether eliminated by distillation.

Another portion of the seed coat was ground to a pulp and extracted with ether. The ether extract was dehydrated with sodium sulphate, filtered, and the ether removed by distilling. The residue was then tested for common oil constants such as saponification and iodine values.

The results of our analysis of the ether extract of the kernels (*Hydnocarpus alcalæ*) from which the brown seed coat was

removed are given in Table 1. There are also included the analysis of the ether extract of the seed coat and the percentage of resin acids obtained from the seed coat. The table also contains analyses of *Hydnocarpus alcalæ* oil made by Brill and by Perkins and Cruz.

TABLE 1.—*Properties of the Philippine oil Hydnocarpus alcalæ.*[a]

	Sample.			
	A	B	C	D
Melting point °C	32	----------	----------	----------
Specific gravity $\frac{30^\circ\ C}{4^\circ}$	0.9502	0.948	0.9438	----------
Specific rotation (100 mm, 30° D)	+49.60	+48.3	+46.1	----------
Iodine value	93.10	94.0	84.1	89.9
Free fatty acids (as oleic)	----------	6.7	0.25	0.57
Saponification value	188.9	202	197.6	197.9
Refractive index $N\frac{30^\circ\ C}{D}$	1.4770	1.4763	1.4765	----------
Unsaponifiable matter	----------	----------	0.45	0.76
Resin acids	----------	----------	None	3.73

[a] Sample A analyzed by Brill; sample B analyzed by Perkins and Cruz; sample C the oil extracted from kernels (*Hydnocarpus alcalæ*) from which the brown seed coat was removed; sample D the oil extracted from the brown seed coat of the kernels.

Specific gravity of sample B determined at $d\frac{30^\circ}{30^\circ}$; iodine number for samples A and B determined by Hanus method and for samples C and D by Wijs.

As shown by the results (Table 1) when the seed coats were removed from the kernels (*Hydnocarpus alcalæ*) the kernels no longer contained any resin acids and had only a slight amount of coloring matter. The seed coats contained 3.73 per cent of resin acids and yielded a dark brown oil. These results indicate that the resin acids which are present in the oil of *Hydnocarpus alcalæ* are contained only in the seed coats of the kernels. Figures for the iodine value, free fatty acids, saponification value, and unsaponifiable matter are higher for the oil obtained from the seed coats than from the oil extracted from kernels without seed coats.

The authors wish to thank Dr. Nemesio Mendiola, of the College of Agriculture, University of the Philippines, who very kindly supplied the photographs for this paper.

SUMMARY

The oil obtained from the Philippine seeds of *Hydnocarpus alcalæ* has a brown color and contains a small amount of resin acids. The coloring matter and resin acids appear to be present

in the seed coats of the kernels of the seeds (*Hydnocarpus alcalæ*). Kernels with seed coats removed gave a white solid fat which contained no resin acids. Oil extracted from the seed coats which were removed from the kernels gave 3.73 per cent of resin acids and an oil of dark brown color.

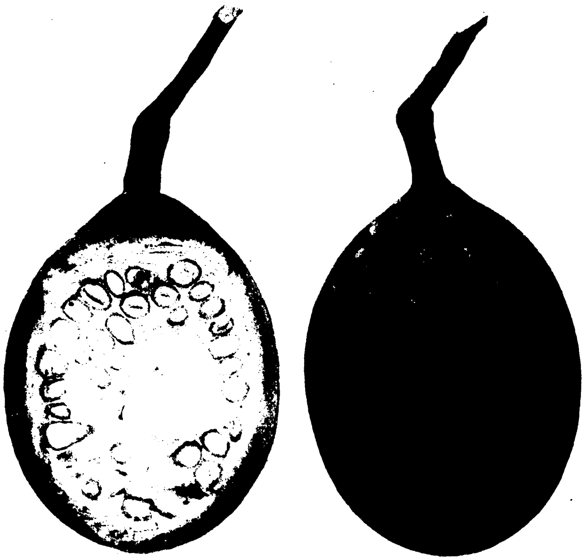
Figures for the iodine value, free fatty acids, saponification value, and unsaponifiable matter are higher for the oil obtained from the seed coats than for the oil extracted from kernels without seed coats.

ILLUSTRATION

PLATE 1

FIG. 1. *Hydnocarpus alcalæ* C. de Candolle, a tree in fruit.
2. *Hydnocarpus alcalæ;* fruit, entire and in longitudinal section.

1



2

PLATE 1. HYDNOCARPUS ALCALÆ.

CHAULMOOGRYL BROM AND CHLOR PHENOLS

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Various derivatives of chaulmoogric acid, such as esters and anilides, have been made from chaulmoogra oil. Recently the synthesis of some chaulmoogryl substituted phenols was completed.[1] This work has been continued, and in the present investigation a few chaulmoogryl halogen phenols were prepared. The method of preparation consisted in treating the acid chloride of chalmoogric acid with various halogen phenols. The results seem to indicate that these compounds may be prepared somewhat easily though the reactions take place rather slowly. The new compounds prepared in this research will be tested for their therapeutic value. In order to check the formulas of these compounds the halogen content was determined. A modified combustion method[2] for the determination of bromine in organic compounds was employed for making the halogen analyses.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was kindly presented to us by Dr. H. I. Cole, of the Philippine Bureau of Health, and was shipped directly to us from the Culion Leper Colony. The oil was prepared from the Philippine seeds of *Hydnocarpus alcalæ* C. de Candolle.

Since the chaulmoogric acid content of this Philippine oil is unusually high, it naturally serves as a good source of material for the preparation of chaulmoogric acid and its derivatives and also chaulmoogryl substituted compounds.[3]

[1] Santos, I. de, and A. P. West, Philip. Journ. Sci. **38** (1929) 293.

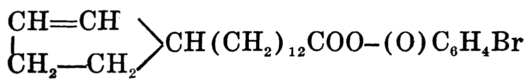
[2] Smith, F. L., Philip. Journ. Sci. **32** (1927) 315.

[3] Herrera-Batteke, P. P., and A. P. West, Philip. Journ. Sci. **31** (1926) 161; Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265, **35** (1928) 405. Santos, I. de, and A. P. West, Philip. Journ. Sci. **38** (1929) 293 and 445 and **40** (1929) 485.

The chaulmoogric acid and acid chloride of chaulmoogric acid were prepared according to the procedure used by Santiago and West.[4] Chaulmoogra oil (600 grams) was saponified with alcoholic potassium hydroxide (200 grams dissolved in 80 cubic centimeters of water and 800 cubic centimeters of aldehyde-free alcohol). The mixture was heated (reflux) on a water bath for about four hours, after which the excess alcohol was removed by distillation. The residual soaps were decomposed with dilute sulphuric acid (1 : 3) and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resins were separated from the acid by filtering. The gasoline was then removed by distillation, and the residue was crystallized several times from alcohol (95 per cent). The melting point was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid with phosphorus trichloride. The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid was allowed to drop slowly into the halogen phenol.

CHAULMOOGRYL O-BROM PHENOL



This compound was prepared by treating the acid chloride of chaulmoogric acid with *o*-brom phenol. Thirty grams of chaulmoogric acid were placed in a flask which was then immersed in hot water until the acid melted. The flask was then connected to a reflux condenser and 3.3 cubic centimeters of phosphorus trichloride were added slowly from a dropping funnel, and the mixture was warmed over a small flame. The reaction was finished in about fifteen minutes. Phosphorous acid separated at the bottom and side of the flask, while the acid chloride remained as a light supernatant liquid. In order to eliminate the phosphorous acid and other impurities the acid chloride was filtered through glass wool and the clear filtrate allowed to drop quickly into 16.1 grams of *o*-brom phenol. The mixture was heated (reflux) in an oil bath to a temperature of about

[4] Philip. Journ. Sci. **33** (1927) 265.

85° C. until the vapors of hydrochloric acid were completely eliminated. To prevent the access of atmospheric moisture, a tube containing calcium chloride was inserted into the top of the reflux condenser. After heating the mixture for about five days the reaction was practically completed. The reaction product was a black oily mass which solidified on cooling. This was dissolved in methyl alcohol and the solution treated with bone black to decolorize it, after which the mixture was filtered through a hot-water funnel. The crystals obtained from the filtrate were recrystallized several times from methyl alcohol containing animal charcoal. The compound thus obtained was a white, amorphous solid which gave a melting point of 51.5 to 53° C. The yield was about 20 per cent.

Solubility experiments show that the chaulmoogryl *o*-brom phenol is insoluble in acetic acid, acetic anhydride, ethyl alcohol, and nitro benzene. It was found to be slightly soluble in methyl benzoate, isopropyl alcohol, and ether, and very soluble in hot methyl alcohol.

Analysis:

	Bromine. Per cent.
Calculated for $C_{24}H_{35}O_2Br$	18.37
Found	18.41

CHAULMOOGRYL O-CHLOR PHENOL

$$\left.\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array}\right\rangle CH(CH_2)_{12}COO{-}(O)C_6H_4Cl$$

The other chaulmoogryl brom and chlor phenols which were prepared were made in a manner similar to that used in the preparation of the chaulmoogryl *o*-brom phenol.

The acid chloride of chaulmoogric acid was prepared first by treating melted chaulmoogric acid (30 grams) with 3.3 cubic centimeters of phosphorus trichloride. The acid chloride thus obtained was filtered through glass wool and allowed to drop quickly into 12.5 grams of *o*-chlor phenol. The mixture was then heated in an oil bath at a temperature of 80° C. for about two weeks in order to complete the reaction. A black, solid, amorphous mass was obtained. The reaction product was crystallized several times from methyl alcohol containing animal charcoal. During the latter crystallization a yellow oil precipitated out of the alcoholic solution as a by-product. This was separated from the alcoholic solution by means of a hot separatory funnel. Experiments were made to convert this yellow

oil into crystals, but they were not successful. When purified, the chaulmoogryl *o*-chlor phenol was obtained as a white amorphous powder. The melting point was 48 to 50° C. The yield was about 25 per cent.

It was found to be insoluble in acetic acid, amyl alcohol, acetic anhydride, ethyl alcohol, ethyl benzoate, glycerin, and nitro benzene. It was slightly soluble in carbon bisulphide, ether, isobutyl alcohol, isopropyl alcohol, and methyl benzoate; it dissolved readily in cold petroleum ether and in hot methyl alcohol.

Analysis:

	Chlorine. Per cent.
Calculated for $C_{24}H_{35}O_2Cl$	9.09
Found	9.26

CHAULMOOGRYL P-CHLOR PHENOL

$$\left.\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array}\right\rangle CH(CH_2)_{12}COO{-}(P)C_6H_4Cl$$

Chaulmoogric acid (30 grams) was melted and treated with 3.3 cubic centimeters of phosphorus trichloride. The acid chloride thus obtained was filtered and allowed to drop quickly into 10.5 cubic centimeters of *p*-chlor phenol. The mixture was heated in an oil bath (100° C.) for five days. The reaction product, which was a dark solid mass, was crystallized several times from petroleum ether containing animal charcoal. The white amorphous powder thus obtained has an oily appearance. When recrystallized from ethyl alcohol white crystals which melted at 53 to 55° C. were obtained. The yield was about 45 per cent.

Chaulmoogryl *p*-chlor phenol is slightly soluble in acetic acid, ethyl alcohol, gasoline, ethyl acetate, xylene, toluene, and absolute alcohol. It dissolves in hot petroleum ether but is more readily soluble in hot methyl alcohol.

Analysis:

	Chlorine. Per cent.
Calculated for $C_{24}H_{35}O_2Cl$	9.09
Found	9.14

CHAULMOOGRYL TRI-BROM PHENOL

$$\left.\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array}\right\rangle CH(CH_2)_{12}COOC_6H_2Br_3$$

The acid chloride of chaulmoogric acid, obtained by the interaction of melted chaulmoogric acid (30 grams) and phospho-

rus trichloride (3.3 cubic centimeters), was added quickly to 31 grams of tri-brom phenol (sym.). The mixture was heated (reflux) in an oil bath (80° C.) for about two weeks. The reaction product was a dark brown mass which was rather oily. It was crystallized several times from petroleum ether containing animal charcoal and afterwards from methyl alcohol. The alcohol seemed to remove the last traces of the oily material. When purified, the reaction product appeared to be a fine white powder which melted at 54 to 56° C. The yield was about 33 per cent.

It is very soluble in acetone, carbon tetrachloride, ethyl acetate, chloroform, methyl benzoate, toluene, hot methyl alcohol, and petroleum ether but only slightly soluble in absolute alcohol, cold methyl alcohol, and petroleum ether.

Analysis:

	Bromine. Per cent.
Calculated for $C_{24}H_{33}O_2Br_3$	40.44
Found	40.55

SUMMARY

Four new compounds were prepared in this investigation; namely, chaulmoogryl *o*-chlor phenol, chaulmoogryl *o*-brom phenol, chaulmoogryl *p*-chlor phenol, and chaulmoogryl tri-brom phenol.

Chaulmoogryl *o*-brom phenol was prepared by treating the acid chloride of chaulmoogric acid with *o*-brom phenol. Chaulmoogryl *o*-chlor phenol was made by the interaction of *o*-chlor phenol and the acid chloride of chaulmoogric acid. By treating *p*-chlor phenol with the acid chloride of chaulmoogric acid there was obtained chaulmoogryl *p*-chlor phenol. Chaulmoogryl tri-brom phenol was prepared by treating the acid chloride of chaulmoogric acid with tri-brom phenol.

Our results indicate that these esters may be made rather easily but the reactions take place very slowly.

THE CONSTITUENTS OF HYDNOCARPUS WIGHTIANA OIL, I [1]

By HOWARD IRVING COLE

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The main constituents of *Hydnocarpus wightiana* oil are the glyceryl esters of hydnocarpic and chaulmoogric acids. The actual amounts of each of these present in the oil have been only roughly estimated.[2] The complete separation of one acid from the other is attended with difficulties.[3] The partial separation of these two constituents may be accomplished by the fractional distillation of their ethyl esters at low pressures.

In this distillation, a low-boiling fraction is obtained which exhibits optical activity. Power and Barrowcliff,[4] working with the fatty acids from *H. wightiana* oil, state that the mother liquor from which the hydnocarpic and chaulmoogric acids have been crystallized would appear to consist of chaulmoogric and hydnocarpic acids together with a still lower homologue of the same series having the formula $C_{14}H_{24}O_2$. In the fractional distillation of the ethyl esters from *H. wightiana* oil at 20 millimeters, Perkins [5] found no evidence of any appreciable quantity of a C_{14} acid, but did find that there was a definite concentration at 160 to 165° C.

ISOLATION OF LAURIC ACID

In an attempt to isolate the lower homologue of hydnocarpic acid referred to, 1 liter of the fraction boiling below 200° C. at 20 millimeters (obtained from about 50 liters of *H. wightiana* ethyl esters), was refractionated several times. The results of the fifth fractionation are shown in Table 1.

[1] Published with the approval of the Director of Health on recommendation of the Philippine Leprosy Research Board.

[2] Perkins, G. A., Journ. Ind. Eng. Chem. **19** (1927) 941.

[3] The large-scale isolation of both acids from *H. wightiana* oil will form the subject of another paper.

[4] Journ. Chem. Soc. **87** (1905) 884.

[5] Journ. Ind. Eng. Chem. **19** (1927) 941.

TABLE 1.—*Fifth fractionation of low-boiling substances in ethyl esters of H. wightiana oil.*

Fraction No.	Degrees C. corrected.	Quantity collected.	Refractive index n D.	Optical activity a D.
	°*C.*	*cc.*		°
1	151–153	95	1.4334	+ 9.0
2	153–155	105	1.4314	+10.0
3	155–157	325	1.4324	+13.5
4	157–159	240	1.4314	+18.5
5	159–161	120	1.4356	+24.3
6	161–163	25	1.4397	+27.1

Eighty grams of fraction 3 were saponified with alcoholic potassium hydroxide and the acid liberated with hydrochloric acid. The melting point of this acid fraction was 37.7° C. It was recrystallized from two volumes of 80 per cent alcohol five times. The crystals were collected on a filter paper, pressed dry, washed several times with hot water, and dried. The melting point of the acids so obtained are shown in Table 2.

TABLE 2.—*Recrystallization of fatty acid from H. wightiana oil.*

Crystallization.	Melting point. °C.
1	39.8
2	43.0
3	43.3
4	43.6
5	43.6

Fractions 4 and 5 crystallized as pure substances do, and proved upon analysis to be lauric acid.

Analysis of substance: 0.2000 gram, 10.0 cubic centimeters of 0.10015 *N* NaOH. Calculated for $C_{21}H_{21}O_2$ equivalent weight, 200; found 200. Melting point lauric acid, 43.6° C.; melting point substance, 43.6° C. Optical rotation and iodine number zero.

In order to obtain some idea of the amount of lauric acid present in *H. wightiana* oil, 2 kilograms of oil were esterified, the esters were washed and dried and then fractionally distilled five times at 20 millimeters. The fraction boiling below 200° C. amounted to 108 grams. This yielded 100 grams of free fatty acids. The lauric acid obtained from this mixture was 24 grams (1.2 per cent).

SEPARATION OF AN OPTICALLY ACTIVE FATTY ACID

The mother liquors from the lauric acid crystallizations were combined. Twitchell's method[6] was used to remove the remaining lauric acid. A residue of 43 grams of liquid fatty acids was obtained and gave an iodine number of 45.6, a neutrality equivalent of 239, and an optical rotation of +24.0°. This liquid was distilled at 20 millimeters, in 10-degree fractions.

TABLE 3.—*Distillation of liquid fatty acids at 20 millimeters.*

Fraction No.	Quantity.	Temperature °C. corrected.	Optical activity.
	g.	°*C.*	°
1	8	150–160	+24.0
2	5	160–170	
3	15	170–178	
4	10	178–185	+30.2

The odors of fractions 1, 2, and 3 indicated that they were contaminated with esters formed during the extraction of the lauric acid by Twitchell's method. These fractions were esterified and distilled at 20 millimeters, passing over between 137 to 152° C. Fraction 4 was obviously still a mixture of acids. It gave an iodine number of 53.8 and a neutrality equivalent of 201.

Fraction 4 was further purified by dissolving it in 95 per cent alcohol and fractionally precipitating the solid fatty acids still remaining in solution by adding small quantities (1 gram) of barium acetate dissolved in the smallest amount of hot water possible. Five precipitations were necessary. The liquid acids remaining in the alcoholic solution were separated by adding hot water, washed several times with water, dried, and distilled at 20 millimeters. Two fractions boiling between 160 and 175° C. and between 175 and 185° C. were obtained. The lower-boiling fraction probably contains some esters. The constants given in Table 4 indicate that fraction 2 contains at least two acids,

TABLE 4.—*Liquid acids from H. wightiana oil.*

Fraction No.	Neutrality equivalent.	Iodine number.	Optical activity.	Refractive index.
			°	
1	244	55.8	21.8	1.4444
2	213	67.2	36.1	1.4504

[6] Journ. Ind. Eng. Chem. 13 (1921) 806.

one of which is saturated and the other unsaturated, exhibiting optical activity. From these results it seems likely that the unsaturated acid when isolated will prove to be a lower homologue of hydnocarpic acid (exhibiting optical activity), and that the saturated acid will prove to be unremoved lauric acid, as the progressive purification of the liquid acids raised the iodine number, neutrality equivalent, and optical activity. This hypothesis would account for the low iodine number and the neutrality equivalent of 213 in fraction 2.

SUMMARY

1. Lauric acid has been isolated from *Hydnocarpus wightiana* oil for the first time.

2. A new, optically active, liquid fatty acid has been obtained from *H. wightiana* oil, but not in sufficient purity to determine its composition. It is probably a lower homologue of hydnocarpic acid.

REDUCTION OF IRRITATION BY IODIZED ETHYL ESTERS OF HYDNOCARPUS WIGHTIANA OIL [1]

By HOWARD IRVING COLE

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TWO PLATES

Ten years ago the injection of crude chaulmoogra oil in the treatment of leprosy was greatly restricted because of its irritant properties. To-day, some workers use refined oils of the chaulmoogra group. Such an oil, from *Hydnocarpus wightiana*, is used here at Culion for some purposes, though not as the main antileprosy drug. This oil is practically non-irritating, but its virtue is in no way reduced; if anything, it is more efficacious than the crude product. However, in certain places, presumably because of the old belief that it is more effective, the crude chaulmoogra oil is still used, as by Johansen [2] who mixes benzocaine with it to alleviate the pain.

While the refined chaulmoogra and *wightiana* oils as made and administered at Culion [3] leave little to be desired in the way of improvement, the fact remains that they are not as effective as the ethyl esters. However, the ethyl esters even when highly purified are undesirably irritating. If a small amount of iodine is added the irritant effects are very markedly reduced, so much so that the iodized ethyl esters are used now on the great majority of the patients at Culion with no untoward effects and very low complaint rates.

Reports from other leprosariums indicate that where the ethyl esters are used, they are much more irritating than those manufactured here. This is of considerable importance, for it is apparently due to this fact that the ethyl esters have not been given the place in leprosy therapeutics that years of experience in the Philippines show they should have, and that where they are used less satisfactory results are obtained. A standard method of manufacture is evidently much to be desired.

[1] Published with the approval of the Director of Health on recommendation of the Philippine Leprosy Research Board.

[2] U. S. Pub. Health Service, Reprint No. 1193 (1927).

[3] Perkins, G. A., Journ. Ind. Eng. Chem. 19 (1927) 939.

A method for the preparation of iodized ethyl esters of low-irritating character is included in this paper.

REDUCTION OF IRRITANT QUALITY BY IODINE

Iodine (2 per cent) was originally added to the esters with the idea that it might serve as a curative agent.[4] After the collapse of this expectation [5] it was still retained [6] because it was found that it reduced considerably the irritation produced by injection. Addition of iodine to the refined oil for this purpose is not necessary, and it is not feasible as it thickens the oil to such an extent as to make the injection extremely difficult.

For several years we have been adding 0.5 per cent iodine instead of 2 per cent to the ethyl esters at it was found to be preferable in several respects.[7] Recent experiments have shown that reduction of iodine content to less than 0.5 per cent led to increase in irritant properties.

Not only is the amount of iodine important but the time and temperature of heating to combine it with the esters has been found to exert a considerable influence on its ability to reduce irritation. Heating for too long a time or to too high a temperature is to be avoided as it leads to the production of irritating decomposition substances. Too short a period of heating or too low a temperature gives a turbid greenish product which is also irritating. It has recently been found that to heat the mixture until it appears brown, without reference to time, is not satisfactory, for the color change does not afford a sharp end point.

Irritation may, however, be caused by other factors, such as impurities, decomposition products formed on heating or chemical treatment, free fatty acids, and the compound itself.

Impurities in the ethyl esters that might cause irritation are largely eliminated in the mode of preparation described below. It has been shown [8] recently that even chemically pure ethyl chaulmoograte and ethyl hydnocarpate with 0.5 per cent iodine cause as much irritation as the iodized mixed esters. This indicates that irritation by the mixed ethyl esters without a modifying

[4] McDonald, Reprint from U. S. Public Health Reports 35, No. 34 (1920).
[5] McDonald and Dean, Journ. Am. Med. Assoc. 76 (1921) 1470.
[6] Hasseltine, U. S. Public Health Bull. 141 (1924) 8.
[7] Wade, H. W., Philip. Journ. Sci. 25 (1924) 710.
[8] Vera, B. de, and C. B. Lara, Journ. Philip. Islands Med. Assoc. in press.

additive such as iodine does not necessarily imply the presence of impurities.

Decomposition products are formed upon heating or chemical treatment but these can be largely blown out with steam.

Free fatty acids are almost entirely eliminated by careful neutralization with sodium hydroxide and by very thorough washing. The maximum free fatty acid content (estimated as oleic acid) that we now allow is 0.2 per cent, but our product seldom contains over 0.1 per cent.

The inherent irritation due to the configuration of the compound is, of course, not removable without changing the compound itself. Although the iodine combines with the ester molecule by elimination of the double bond in the pentene ring, the actual amount present is sufficient to saturate only about 0.5 per cent of the molecules. If the reduction of irritation were due to this saturation, we would expect the reduction to be very slight, while as a matter of fact, it is very marked. Furthermore, 2 per cent iodine does not reduce the irritation to any greater extent than does 0.5 per cent. It has been thought in the past that there might be present in the esters a very small amount of highly irritating impurities with which the iodine tends especially to combine, but it is not certain that such impurities are present for especially purified products retain their irritant quality. A satisfactory explanation of the cause of the reduction of irritation by the addition of iodine is yet to be given.

We cannot expect to secure much further reduction in irritating properties in the ethyl esters by further lowering of free fatty acid content, since that is now as low as it is practicable to make it, or from further elimination of impurities since, as has been said, it has been shown that mixed esters are at present no more irritating than the chemically pure ethyl hydnocarpate itself. There remain then the possibilities (1) of reducing the amount of decomposition products either by less strenuous treatment in the preparation of the esters or by longer blowing out with steam and (2) of so adjusting the time-temperature factor, after adding iodine, as to secure the maximum reduction of the inherent irritant quality and to avoid secondary production of decomposition products.

To use less strenous treatment in the preparation of the esters than we do at present is impracticable. Increasing the time

of blowing out with steam beyond two hours leads to no improved results.

Until recently, our method of heating with iodine was "to heat at 150° C. to a brown color."[9] It is difficult to reproduce this color exactly by eye alone. Consequently, if this criterion is used, various lots may differ in the time of heating. It has been our experience that from time to time the esters with 0.5 per cent iodine have been markedly more irritant than usual, and the cause was finally determined to be variations in the time of heating to obtain this color end point. Therefore, a series of experiments was made to show the relation of time and temperature of heating to the amount of irritation produced on injection.

Ten liters of dry purified mixed ethyl esters of *H. wightiana* oil were heated in an open kettle to 140° C.; this took 30 minutes. Fifty grams of iodine (Mallinckrodt, U. S. P. resubl.) were added with stirring. The temperature immediately rose and was maintained at 150° C. A two-liter sample was dipped out 15 minutes after the iodine was added, another 15 minutes later and so on until five samples were obtained, representing 15, 30, 45, 60, and 75 minutes heating with iodine at 150° C. The samples were then cooled, filtered into 250-cubic centimeter bottles, and sterilized in a hot-air oven for one hour at 150° C. In this time the actual temperature of the liquid in the bottles reached only 110° C. These lots were labeled 1, 2, 3, 4, 5. Five groups of approximately 300 lepers each were injected once with the different lots by the medical staff.

TABLE 1.—*Irritation produced by ethyl esters of Hydnocarpus wightiana oil with 0.5 per cent iodine.*[a]

Lot No.	Time of heating with iodine at 150 °C.	Number of patients.	Immediate complaints.		Late complaints.				
			Number of patients.	Per cent.	Number of patients.	Induration.		General.	
						Number.	Per cent.	Number.	Per cent.
	Min.								
1	15	332	101	30.4	325	39	12.0	55	17.0
2	30	298	46	15.4	325	35	10.8	26	8.0
3	45	320	39	12.2	308	19	6.2	32	10.4
4	60	323	44	13.6	330	25	7.5	23	7.0
5	75	283	74	26.2	346	37	10.7	70	20.2

[a] These data were kindly furnished by the medical section, Dr. C. B. Lara, chief physician in charge. Five cubic centimeters were injected in each patient by the Plancha method.

[9] Perkins, G. A., Philip. Journ. Sci. 24 (1924) 630.

It is seen from Table 1 that too short as well as too long a heating leads to markedly greater irritation. In the former case, it is obviously due to uncombined iodine; in the latter, it is probably due to formation of decomposition products. These lots were used within a day after being prepared and at that time showed a gradation of color and clarity from a turbid brownish green in No. 1 to a pure clear brown in No. 5. At the end of two weeks, however, lots 2, 3, 4, and 5 were all of the same clear brown color. Lot 1 was still a turbid brownish green at the end of two months. This would indicate that the reaction between the iodine and the esters goes to completion in from sixty to seventy-five minutes at 150° C., but that, on the other hand, it takes two weeks to go to completion at room temperature (30° C. maximum) when heated with the iodine for only thirty minutes at 150° C. In view of the above facts, heating at a temperature lower than 150° C. is not considered feasible.

Since the reaction went to completion even at room temperature in lots 2 and 3 in two weeks time, 10 liters of each of these were again made up and stored for two weeks before being used. The results of treating 3,000 cases with these two lots indicated that lot 2 was as nonirritating as lot 3. It was therefore decided that for routine production the mixture should be heated at 150° C. for only thirty minutes and stored for two weeks before using, thus securing the maximum effect of the iodine with the least opportunity for the formation of decomposition products.

PRESENT METHOD OF MANUFACTURE OF MIXED ETHYL ESTERS OF CHAULMOOGRA-GROUP OILS

Esterification.—The esterification is conducted as described by Perkins [10] but is included here for the sake of completeness. Ten liters of *H. wightiana* oil are boiled vigorously for forty-eight hours with 5 liters of 95.5 per cent ethyl alcohol and 100 mils of concentrated sulphuric acid. The principal advantage of vigorous boiling is undoubtedly that it keeps the two layers well mixed. In our plant the boiling is done in stoneware acid carboys of 26-liter capacity set in concrete tubs which serve as steam jackets. The alcohol vapor is condensed by a reflux condenser made of 13-millimeter brass pipe, 1.5 meters long with water jackets of 38-millimeter galvanized iron pipe soldered on (Plate 1). The contents of the carboy are washed three times

[10] Philip. Journ. Sci. 24 (1924) 627.

with about 20 liters of water and then dried in a steam kettle. The yield from 10 liters of oil is about 11 liters of esters. If desired the first washing may be neutralized with lime and fractionally distilled to recover the alcohol.

Distillation.—The washed and dried ethyl esters are then distilled at 20 to 25 millimeters pressure. The still used in our laboratory is made by welding a cap on one end of a piece of 15-centimeter iron pipe, 30 centimeters long, and a 15 by 5 centimeter reducing coupling on the other end. Into this coupling is screwed a still head of extra heavy iron pipe with a vacuum connection at a T (Plate 2). A wrapping of twenty-five turns of No. 22 chromel A wire around the still head is used for auxiliary electric heating (110 volts). Loosely fitting asbestocel pipe covering forms a hot-air bath for the still and still head throughout its entire length. Heating is done by means of a large kerosene burner (Manning No. 6) as gas is not available. After about 30 liters have been distilled, the residue while hot is removed through a hole near the bottom of the still. After a month of continuous use the still head is unscrewed, the body and head are heated in a fire until the spongy residue becomes brittle, and the contents are scraped out.

Washing with alkali.—Five hundred grams of lye (94 per cent sodium hydroxide) are dissolved in 80 liters of hot water 90° C.) in a 160-liter steel drum. Forty-five liters of the distilled ethyl esters (2.5 to 3 per cent acidity) are thoroughly mixed in. After the mixture has stood for twenty-four hours the clear lower layer is drawn off through an outlet in the bottom of the tank. Hot water (90° C.) is added to the 140-liter mark, thoroughly mixed in, allowed to settle for twenty-four hours, and again drawn off. The washing with water is repeated thus four times with twenty-four hours settling each time. The yield is about 96 per cent and the acidity (as oleic acid) is usually under 0.1 per cent. About 15 liters of the washed esters are put in a 26-liter stoneware carboy and steam is passed through it for two hours or longer until the sharp odor produced by heating has disappeared. The esters are placed in ordinary 5-gallon oil tins to settle and then poured off from the separated water and filtered through paper. The product is a clear, very pale yellow, mobile liquid with a slight characteristic odor.

Addition of iodine.—Fifteen liters of the purified esters are heated in a 20-liter enameled kettle to 140° C. They must be

thoroughly dried.[11] Seven and five-tenths grams of U. S. P. resublimed iodine is added with stirring. The temperature immediately rises to 150° C. at which point it is maintained for thirty minutes and is stirred occasionally. After cooling, the iodized esters are filtered into bottles (250 cubic centimeters capacity) and sterilized for one hour in an oven at 150° C. The temperature of the contents of the bottles reaches in this time 110° C. The bottles are corked and sealed with paraffin or sealing wax and allowed to stand two weeks before using. A time limit of two years is set on the use of the esters although samples which have stood longer than three years do not seem to have deteriorated sufficiently to become markedly irritating.

SUMMARY

1. The factors governing irritation by iodized ethyl esters of *Hydnocarpus wightiana* oil are discussed.

2. Experiments show that too long as well as too short a time of heating of the esters with iodine leads to increase in irritant properties.

3. A method for the manufacture of iodized ethyl esters that reduces irritant properties to a minimum is described.

4. A more accurate control of the heating with iodine by means of a time-temperature factor eliminates the occasional increase in irritant properties of the iodized esters due to the inaccuracy of a color end point.

[11] "The esters must be thoroughly dried before iodine is added since the latter effects by catalysis the hydrolysis of several per cent of the esters if water is present."—Perkins, G. A., Philip. Journ. Sci. 24 (1924) 630. If the filtered esters are clear, the heating to 140° C. before adding the iodine will drive off all the dissolved water.

ILLUSTRATIONS

Views of the leprosy drug plant at Culion Leper Colony. (Photographs by Merl LaVoy.)

PLATE 1

A portion of the chemical plant showing the concrete steam tubs and metal condensers used for the esterification of *Hydnocarpus wightiana* oil.

PLATE 2

A portion of the chemical plant showing a near view of the vacuum still and the bottling of the iodized ethyl esters of *Hydnocarpus wightiana* oil.

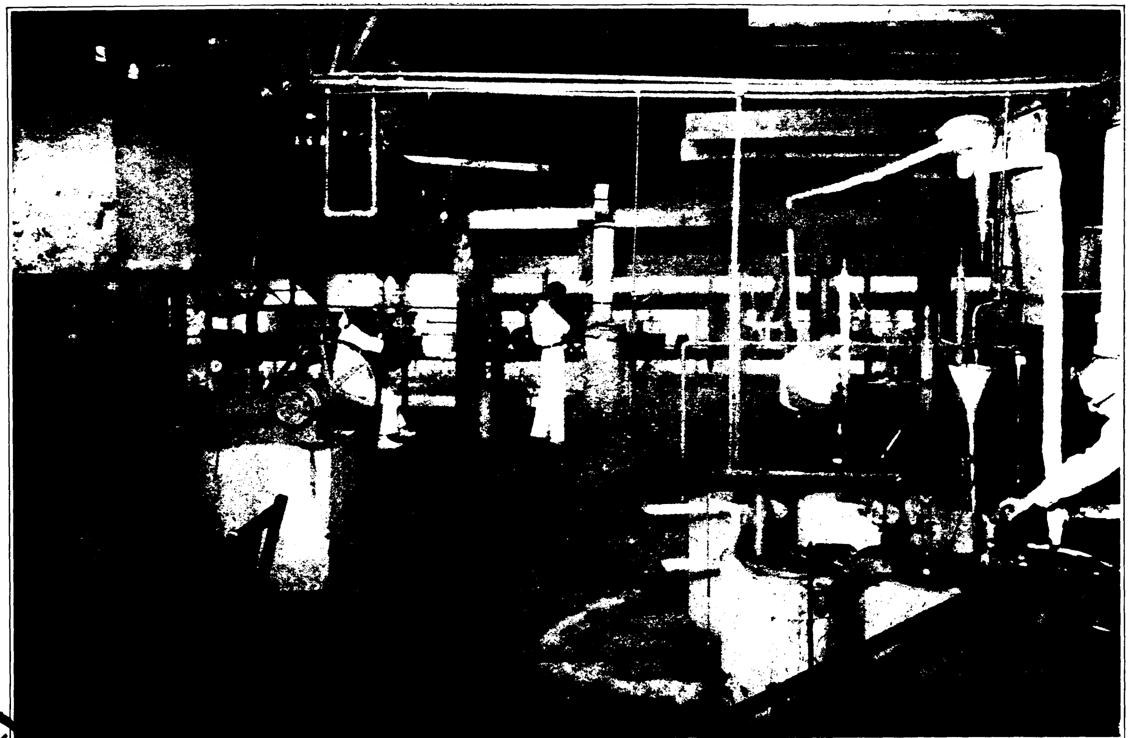

PLATE 1. CONCRETE STEAM TUBS AND METAL CONDENSERS.

PLATE 2. THE VACUUM STILL AND BOTTLING TABLES.

SEGUIDILLAS BEAN

By F. Agcaoili

Of the Division of Organic Chemistry, Bureau of Science, Manila

Many analyses of several varieties of beans are to be found in the literature. Some of these beans are valued more or less because of their nitrogenous elements and others because of their carbohydrate content. The bean of *Psophocarpus tetragonolobus* (Linnæus) de Candolle is known in Tagalog as "seguidillas" or "calamismis," in Ilocano as "pal-lang," and in English as the "asparagus bean." This paper shows the food value of the dried seed of seguidillas as compared with that of soya bean.

The botanical description of the plant follows:[1]

A glabrous, twining, annual vine reaching a length of 6 m or more. Leaves 3-foliolate, leaflets ovate, entire, acuminate, 8 to 14 cm long, base deltoid. Racemes few-flowered up to 15 cm in length. Flowers light-blue, 3 to 3.5 cm long. Pod square, 10 to 20 cm long, about 2 cm thick, 4-winged, the wings about 5 mm wide, crisped. (Fl. Filip, *pl. 293.*)

Commonly cultivated for its edible pods, occasionally spontaneous, fl. Oct.–Dec., certainly introduced. India and Malaya.

The bean, or seed, is edible when cooked and has a skin similar to that of the soya bean. The skin constitutes 12 per cent and the kernel 88 per cent, by weight, of the bean.

The dry bean is brown and is slightly veined with dark brown streaks. It is rounded and laterally compressed, and is about 10 millimeters in length, 8 millimeters in width, and 7 millimeters in thickness. The hilum which is situated at the lateral side is 4 millimeters long and 2.5 millimeters wide. The skin is smooth and shiny.

Table 1 shows the results of the analysis of the whole seeds in comparison with the corresponding figures for soya bean.

The oil was extracted from the crushed seeds with ether, and analyzed. The results are shown in Table 2, which includes for comparison the figures for soya-bean oil.

The seed when tested for prussic acid gave a negative result.

[1] Merrill, E. D., A Flora of Manila, Bur. Sci. Publ. 2 (1912) 264.

TABLE 1.—*Analysis of seguidillas and soya beans.*

Constituent.	Seguidillas.	Soya bean.[a]
	Per cent.	*Per cent.*
Moisture	9.74	9.84
Fat	17.04	18.97
Protein (N×6.25)	32.81	37.53
Starch	12.50	
Carbohydrates other then starch, by difference	18.70	
Ash	4.01	4.79
Crude fiber	5.20	

[a] Philip. Journ. Sci. § A 7 (1912) 48.

TABLE 2.—*Analysis of sguidillas and soya-bean oils.*

	Seguidillas.	Soya bean.
Refractive index 30°C	1.4666	1.4652
Refractive index Zeiss 30°C	62.8	79.0
Specific gravity 30°C	0.9284	0.9310
Saponification number	175.6	189.3
Iodine number	82.1	71.0

The ease with which the crop may be grown and harvested and the possibilities of the seed for the production of edible oil and food stuffs are main factors for the encouragement of its development. Furthermore, the climate of the Philippine Islands is admirably adapted for its extensive cultivation. It does not require special soil or care for its growth.

In China, Japan, and the Philippines soya bean is used for the manufacture of many varieties of food products. The similarity of the seguidillas bean to the soya bean in almost all its components leads to the conclusion that whatever uses can be made of the latter may also be made of the former. The oil extracted from the bean may be utilized for culinary purposes and for the manufacture of soap. The cake makes an excellent nitrogenous foodstuff which may be used as human food or as stock feed. The young pods when boiled with water and seasoned to taste make delicious greens similar to string beans in flavor.

SUMMARY

Characteristic samples of seguidillas beans and the oil obtained from the seeds of these beans were analyzed. The results obtained compare favorably with the corresponding data given in the literature for soya beans.

AN INEXPENSIVE METHOD FOR IMPROVING THE APPEARANCE OF BUNTAL FIBER OR OF ARTICLES MADE OF SUCH MATERIAL

By SALVADOR DEL MUNDO

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The Bureau of Science receives many requests for information in regard to a comparatively inexpensive process for improving the appearance of buntal fiber, not only from various local hat dealers and commercial houses exporting native hats and fiber, but also from private parties. Information that may be valuable to the various people who are interested in the subject is given in this paper.

Buntal is the name given to the flexible material obtained from the fibrous bundles of the petiole of the matured leaf of buri palm, *Corypha elata*.[1] When recently and properly pulled from the petiole, these fibers are white and glossy, but when exposed to air and light they become discolored and acquire an ugly brownish tint. The fiber is extensively woven into baskets, handbags, and similar household articles of commercial value, but by far its most important industrial application is in the making of hats which are sold under the name of buntal Baliuag or Lucban, accordingly as the hats have been made in Baliuag, Bulacan, or in Lucban, Tayabas. Buntal hats have met with favorable reception in foreign countries and the demand has created a profitable home industry. By request of local firms engaged in exporting native hats, experiments were performed in this laboratory with a view of evolving a comparatively cheap process of improving the appearance of buntal fiber or hats.

In evolving the process outlined below, it was not the primary object to produce a perfect bleach such as may be accomplished with the use of more powerful bleaching agents, sodium peroxide for example. Rather, certain desirable features were borne in mind and duly incorporated in the method; namely, the relative low cost of materials required, the absence of any injurious

[1] See also Bureau of Education Technical Bull. 3 (1914) and the Philippine Craftsman 31 (1914) 45.

effect on buntal fiber, and the relative ease of manipulation involved. The present process was tried and thoroughly tested with a number of Baliuag and Lucban hats, and the results obtained were satisfactory even when the operator was inexperienced in the art of bleaching.

METHOD

Materials.—Two solutions are required, a bleaching agent to be designated as solution 1, and a decolorizing bath designated as solution 2.

Solution 1:	Parts.
Commercial potassium permanganate	5
Commercial sodium carbonate (dry)	2
Water	1,000

Preparation.—Measure out the required quantity of water. Add the solid ingredients a few portions at a time, stirring briskly to aid in dissolving the solid particles. To secure a homogeneous solution, continue stirring for some time after the complete solution of the solid chemicals.

Solution 2:	Parts.
Hypo (sodium thiosulphate)	20
Water	1,000
Dilute sulphuric acid sufficient to render acid.	
Note: Acidify solution 2 when it is ready for use.	

Preparation.—Pour the weighed amount of hypo into the measured quantity of water, a little at a time and with constant agitation. When all the hypo has dissolved, pour in about 2 cubic centimeters of commercial sulphuric acid for each liter of hypo solution. An excess of acid should be avoided. Stir. Note the evolution of a peculiar, pungent odor in the acidified hypo solution. The gas which causes this odor effects decolorization, and the absence of odor would tend to indicate that solution 2 is weak, in which case more acid should be added. Solution 2 becomes milky white in time on account of precipitated sulphur, but the turbidity is harmless and should cause no alarm.

PROCEDURE

Immerse the fiber or hats in solution 1; keep them there until they acquire a dark brown stain due to permanganate. The longer the hats are kept in solution 1, the better the bleach obtained. On the other hand, more time is required to decolorize the permanganate stain with solution 2. A little practice will enable one to determine when to remove the hats from solution 1. A bleach is usually secured after an immersion of from

one to two hours. A somewhat longer period is required when the solutions become weak. Solution 1 may be used repeatedly until it fails to stain the immersed hats to the required tint; when, of course, the solution may be strengthened by the addition of some crystals of potassium permanganate. A badly spent solution should be discarded.

When the immersed hats have become sufficiently darkened by exposure to permanganate, remove them from solution 1. Rinse well with water to remove the excess of permanganate and transfer to solution 2.

Keep the hats in solution 2 (with occasional shaking) until the brown stain acquired from the previous treatment is completely decolorized. If decolorization proceeds rather too slowly, a few more drops of acid should be added to solution 2. Too much acid should be avoided as it is detrimental to the fiber. Slow decolorization is commendable as it imparts a glossy finish to the bleached surface. When the stained hats have become completely decolorized, remove them from solution 2, and wash them well with water (running water preferred). If a piece of blue litmus paper is available, test for complete removal of residual acidity. The hats may now be set out to dry.

When solution 2 becomes too weak from continuous use or from prolonged standing, it often happens that the stains produced by the previous immersion in solution 1 are removed only with considerable difficulty or, in some cases, the stains are not removed at all; much, of course, to the alarm of the operator. Should this happen, a simple remedy lies in regenerating solution 2 by the addition of a few more drops of acid, or should it be feared to introduce too large an excess of acid, a freshly prepared solution should be secured.

Potassium permanganate is the only expensive chemical used in this process, but the amount of it required is so small as to make the expense from this source no drawback at all. Sodium carbonate is used to give solution 1 an alkaline reaction. It serves as a detergent for greasy material which may adhere to the fiber surface and hinder the bleaching action of permanganate. Sodium carbonate as well as hypo may be secured from any druggist at a low cost.

Very little attention is required by the method outlined above. After the hats have been dumped into the bleaching or decolorizing baths, all the attention required is occasional shaking and stirring. The procedure should cause no trouble even in the hands of beginners and inexperienced operators.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), V [1]

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

TWO PLATES

The crane flies discussed at the present time are almost entirely from the mountains of Formosa, where they were collected by my friend Prof. Syuti Issiki. The most interesting series are those taken at Shōrei (Syōrei) at an altitude of 7,000 to 8,000 feet, in late October, representing a tipulid fauna that is quite characteristic of the Palæarctic Region in autumn. I am very greatly indebted to Professor Issiki for the privilege of retaining the types of the novelties described at this time.

In the present report, nine genera and subgenera of Tipulidæ are added to the Formosan fauna; namely, *Stibadocerella, Cyttaromyia, Discobola, Thaumastoptera, Ula, Troglophila, Pilaria, Cladura,* and *Neolimnophila.* This brings the total of generic and subgeneric groups for the island to more than seventy, a number that is greater than that of Europe or of America north of Mexico. The additional groups found in the major islands of Japan bring the number for the Japanese Empire to approximately one hundred, with several additional genera and subgenera that are regional and will almost certainly be taken as a result of future collecting.

TIPULINÆ

NESOPEZA BASISTYLATA sp. nov.

General coloration yellowish brown, the mesonotal præscutum with a narrow brown median vitta; antennæ relatively long, the basal segments yellow, the flagellum black; verticils of flagellar segments short; femora and tibiæ yellowish brown, the tarsi chiefly snowy white; wings suffused with brown, the stigma darker; abdomen dark brown, the segments ringed with yellow, especially the sternites; male hypopygium with the basistyles

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

greatly produced into slender arms that are tufted with black setæ.

Male.—Length, about 8.5 millimeters; wing, 9.5; antennæ, about 3.3.

Female.—Length, about 8.5 millimeters; wing, 9.3.

Frontal prolongation of head pale brown, darker medially above; palpi dark brown. Antennæ (male) relatively long, the basal segments obscure yellow, the flagellar segments beyond the first passing into brownish black; flagellar segments elongate-cylindrical, gradually decreasing in length outwardly, clothed with a short, erect, pale pubescence and slightly longer black verticils that are more or less unilaterally arranged and shorter than the segments themselves. Head light brown.

Pronotum dark brown. Mesonotal præscutum rather light yellowish brown, with a narrow brown median line; posterior sclerites of mesonotum somewhat darker, especially the postnotal mediotergite; humeral region of præscutum restrictedly pale yellow. Pleura pale, the sternopleurite and meron darker, producing a more or less distinct longitudinally striped appearance. Halteres elongate, dark brown, the base of the stem restrictedly yellow. Legs with the coxæ yellowish testaceous; trochanters pale yellow; femora and tibiæ yellowish brown, the tarsi chiefly snowy white. Wings (Plate 1, fig. 1) with a strong brownish suffusion, the costal and apical regions somewhat darker; stigma conspicuous, dark brown, irregular in outline, oval, with a basal extension in cell Sc_1 almost to the fork of Sc; cord vaguely seamed with darker; a feebly indicated pale antestigmal spot; veins dark brown, the obliterative areas restricted. Venation: Sc_1 lacking; Sc_2 at near three-fourths the length of Rs, the latter arcuated; forks of medial field relatively shallow; m-cu at less than one-half its length before the fork of M.

Abdominal tergites chieflly dark brown, the basal segments with a yellowish triangle on either side at near midlength; sternites even more conspicuously banded, dark brown, the extreme base narrowly yellow, with an additional wider yellow ring at near midlength of the sclerite; subterminal segments with the basal pale ring lacking, becoming more uniformly darkened; hypopygium chiefly yellow. In the female, the banded abdominal pattern is much less distinct. Male hypopygium (Plate 2, fig. 25) with the ninth tergite, *9t*, having the caudal margin blackened, trilobed, the lateral lobes larger and wider, the me-

dian lobe very low; on ventral surface back from each lateral lobe extends a blackened serrated bar. Basistyle, *b*, very greatly produced caudad, before midlength on mesal face with a tumid swelling set with abundant microscopic setulæ; beyond this enlargement, the style is slender, curved gently mesad, at apex with a tuft of black setæ. Outer dististyle, *od*, long and slender.

Habitat.—Formosa.

Holotype, male, Rantaizan, altitude 4,000 to 6,000 feet, May 20, 1928 (*S. Issiki*). Allotopotype, female.

CYLINDROTOMINÆ

Genus STIBADOCERELLA Brunetti

Stibadocerella BRUNETTI, Rec. Indian Mus. 15 (1918) 283.
Agastomyia DE MEIJERE, Bijd. tot de Dierkunde 21 (1919) 17.

The genus *Stibadocerella* has been represented only by two closely allied species, *S. pristina* Brunetti, from the Garo Hills, Assam, altitude 3,500 to 3,900 feet, collected in July by Kemp; and *S. albitarsis* (de Meijere) from Korinchi, Sumatra, taken in September by Jacobson. The discovery of a third closely allied species in Formosa is thus of great interest.

STIBADOCERELLA FORMOSENSIS sp. nov.

Thorax polished reddish brown, without distinct stripes; body with strong greenish tints; tips of fore tibiæ broadly white; wings with the second section of Rs longer than R_{4+5}, cell R_3 being relatively small; cell 1st M_2 large, exceeding the longest vein beyond it.

Female.—Length, about 12 millimeters; wing, 9.2.

Rostrum and palpi greenish brown. Antennæ with the scapal segments green, the flagellum black; antennæ about as long as the combined head and thorax. Head broad, greenish brown.

Mesonotum polished reddish brown, without distinct stripes, the margins and posterior sclerites with greenish tints. Halteres brownish black. Legs with the coxæ and trochanters green; femora brownish black; tibiæ black, the base narrowly ringed with white, more broadly so on the fore tibiæ; tips of fore tibiæ broadly white (2 millimeters); fore basitarsi much shorter than the tibiæ, black, the extreme tip pale; remainder of tarsi snowy white; posterior legs stouter, the tips of the tibiæ darkened; basitarsi with about the distal fourth white. Wings (Plate 1, fig. 2) with the coloration as in the other species, nearly hyaline, with very distinct black veins; stigma lacking. Venation: Basal section of Rs nearly straight, subequal to the second section;

R_{2+3} subperpendicular; R_{4+5} distinctly shorter than the second section of Rs, cell R_3 relatively short; cell 1st M_2 very large, exceeding in length the cells beyond, the second section of M_{1+2} equal to the outer section; m–cu longer than the distal section of Cu_1; vein 2d A represented by a marginal thickening to nearly opposite midlength of cell 1st A.

Abdomen chiefly greenish brown. Ovipositor with the valves unusually developed for a member of the Cylindrotominæ, the tergal valves especially well-formed, margined with conspicuous setæ, the basal half of the valve blackened, the outer half paling to green.

Habitat.—Formosa.

Holotype, female, Rantaizan, 4,000 to 6,000 feet, May 20, 1928 (*S. Issiki*).

It has generally been assumed that the second anal vein was lacking in this genus, but this is not exactly true. It is represented by an axillary marginal thickening, the cell itself being reduced to a linear strip lying proximad of the level of the arculus.

Through the kindness of Dr. Singh Pruthi, I have been able to examine a paratype of *S. pristina* Brunetti and have included a few supplementary notes concerning this species:

Male.—Length, about 10 millimeters; wing, 9.2; antennæ, about 13.

Antennæ (male) much longer than the body, as shown by the measurements, pale yellow, the outer segments of the flagellum darker. Body coloration as described by Brunetti. Præscutal stripes distinctly separated. Pale ring at base of tibiæ distinct; pale apex of fore tibiæ relatively wide (1.7 millimeters), slightly thickened, the setæ similarly white; fore and middle basitarsi about as long as the respective tibiæ, brown, only the extreme tips of each a little whitened. Wings (Plate 1, fig. 3) hyaline, the veins black. Venation: Sc_1 ending before r-m, Sc_2 at its tip; second section of Rs a little shorter than the basal section; R_{2+3} oblique; free tip of Sc_2 and R_{1+2} entirely atrophied; cell 1st M_2 large, roughly rectangular; m-cu longer than the distal section of Cu_1, vein Cu_2 evident to opposite m-cu; vein 1st A long, nearly straight; vein 2d A very short, opposite the arculus becoming confluent with the anal margin of the wing.

Genus CYTTAROMYIA Scudder

Cyttaromyia SCUDDER, Bull. U. S. Geol. Geogr. Surv. Terr. 3 (1877) 751; Proc. Am. Phil. Soc. 32 (1894) 190–194.

The genus *Cyttaromyia* has been known only from the Tertiary, having been especially characteristic of the Florissant beds of Colorado (Miocene). I am referring to this genus with some question a remarkable cylindrotomine fly from Formosa that is certainly distinct from *Cylindrotoma*. The venation of one wing of the unique type of the present species conforms closely to the essential features of the known species of *Cyttaromyia,* but the opposite wing has lost the supernumerary cross-vein in cell R_5 that furnishes the chief character of the genus. The most notable features of the present fly are the very large, nearly contiguous eyes, the coarsely punctured thoracic dorsum and pleura (which reminds one strongly of the otherwise distinct *Stibadocera*), and the venation, cell M_1 being present, connected with vein R_{4+5} by a supernumerary or adventitious cross-vein, forming an accessory discal cell immediately above the true cell 1st M (Plate 1, fig. 4), the last feature possibly not constant. It should be noted that the present fly disagrees with Scudder's definition of *Cyttaromyia* in the loss of Sc_1 and in the presence of tibial spurs.

CYTTAROMYIA TAIWANIA sp. nov.

General coloration black, the thorax coarsely punctured; antennæ (male) elongate, nearly as long as the body, the flagellar segments cylindrical, with short verticils; eyes (male) almost contiguous on anterior vertex.

Male—Length, about 7 millimeters; wing, 7; antennæ, about 6.5.

Rostrum and palpi black. Antennæ dark brown, in male nearly as long as the body; flagellar segments elongate-cylindrical, with scattered pubescence and verticils that are much shorter than the segments; antennal segments broken beyond the twelfth; flagellar segments gradually increasing in length to the fifth or sixth, thence shortening outwardly. Head dull black, impunctate; eyes large, with coarse ommatidia, in the male almost contiguous on the anterior vertex.

Mesonotum black, the surface with conspicuous coarse punctures, the three præscutal stripes and centers of the scutal lobes nearly smooth. Pleura black, the extensive dorsopleural membrane pale yellow; pleura, except the sternopleurite, with numerous coarse punctures. Halteres elongate, infuscated, the base of the stem narrowly pale yellow. Legs with the coxæ smooth, brownish black; trochanters obscure yellow; femora obscure yellow, the tips slightly more infuscated; tibiæ brownish yellow,

the tips very narrowly darkened; tarsi obscure yellow, passing into black. Wings (Plate 1, fig. 4) with a uniform grayish brown suffusion, without a stigma; veins dark brown. Venation: Sc_1 lacking, Sc_2 ending just before the fork of Rs; Rs long, arcuated at origin, in alignment with R_{4+5}; R_{2+3} interstitial with r-m, arising at end of Rs; free tip of Sc_2 preserved; distal end of R_2 entirely atrophied; a supernumerary crossvein in cell R_5 of the right wing of type, lacking in the left wing; medial field as in *Cylindrotoma;* m before to just beyond the fork of M_{1+2}; m-cu beyond midlength of cell 1st M_2, subequal to the distal section of Cu_1.

Abdomen elongate, brownish black, nearly smooth except for the transverse impressed areas; hypopygium black.

Habitat.—Formosa.

Holotype, male, Rantaizan, altitude 4,000 to 6,000 feet, May 20, 1928 (*S. Issiki*).

LIMONIINÆ

LIMONIINI

LIMONIA (LIBNOTES) CLITELLIGERA sp. nov.

Thorasic dorsum chiefly polished black; pleura, pleurotergite, and scutellum reddish yellow; femora obscure yellow, the tips weakly darkened; wings grayish, the cells beyond the cord strongly darkened; most veins of wing seamed with brown; Sc long; R_2 and free tip of Sc_2 in transverse alignment; m-cu beyond fork of M; anal veins divergent.

Female.—Length, about 8 millimeters; wing, 9.

Rostrum and palpi dark brown; terminal segment of maxillary palpi small. Antennæ black throughout; flagellar segments with the verticils of upper surface very long, arranged unilaterally in pairs; outer flagellar segments elongate. Head dull black, the restricted frons gray; eyes large, nearly contiguous on the dorsum, restricting the anterior vertex at this point to a linear strip.

Pronotum, mesonotal præscutum, and scutal lobes polished black, the humeral region of the præscutum very restrictedly pale; median region of scutum and scutellum reddish brown; postnotal mediotergite black. Pleura and pleurotergite uniformly reddish yellow, including the dorsopleural membrane. Halteres obscure yellow, the knobs dark brown. Legs with the coxæ and tronchanters reddish yellow; femora obscure yellow, the tips weakly darkened; remainder of legs obscure yellow, the terminal tarsal segments black; legs relatively long and slender.

Wings (Plate 1, fig. 5) dimidiate, the cells beyond the cord strongly darkened, the basal cells more grayish; costal region, and especially cell Sc, more darkened; stigma short-oval, brown; prearcular cells and axillary region darkened; a large cloud at origin of Rs; narrow but conspicuous brown seams along Cu, the cord and outer end of cell 1st M_2; other longitudinal veins less distinctly seamed with brown; veins dark brown. Venation: Sc very long, ending some distance beyond r-m; R_2 and free tip of Sc_2 pale, in transverse alignment; Rs arcuated at origin, more than three times the basal section of R_{4+5}; radial veins long, generally parallel cell 1st M_2 relatively small; m-cu a little less than its length beyond the fork of M; anal veins gently divergent at base.

Abdominal tergites dark brown, the outer segments more reddish brown; sternites more yellowish brown. Ovipositor with the genital segment obscure yellow; tergal valves slender, gently curved; sternal valves stouter, their bases darkened.

Habitat.—Formosa.

Holotype, female, Rantaizan, altitude 4,000 to 6,000 feet, May 20, 1928 (*S. Issiki*).

The peculiar body coloration and wing pattern readily separate the present species from other described species of *Libnotes*.

LIMONIA (LIMONIA) TENUICULA sp. nov.

General coloration yellowish brown, the præscutum with a median dark brown discal area; antennæ moniliform, black throughout; wings with a pale brown tinge, the stigma darker; Sc_1 ending beyond midlength of Rs; inner end of cell 1st M_2 strongly arcuated; m-cu beyond the fork of M; male hypopygium with the ventral dististyle small, the rostral prolongation small, without spines.

Male.—Length, about 4.5 millimeters; wing, 5.5.

Rostrum and palpi brownish black. Antennæ brownish black throughout; flagellar segments strongly nodulose, the segments short-oval with glabrous apical necks; terminal segment elongate, narrowed to a point. Head dark blackish gray.

Mesonotal præscutum brownish yellow, the disk polished dark brown to brownish black, restricting the ground color to the humeral and lateral portions; remainder of mesonotum dark brown. Pleura yellowish brown. Halteres relatively short, dark brown, the base of the stem narrowly yellow. Legs with the coxæ and trochanters yellowish testaceous; femora pale brown, passing to darker at tips; tibiæ and tarsi pale brownish

yellow, the terminal tarsal segments darker. Wings (Plate 1, fig. 6) relatively narrow, with a pale brownish tinge, the short-oval stigma darker brown; veins dark brown. Venation: Sc relatively long, Sc_1 ending shortly beyond midlength of Rs, Sc_2 at its tip; free tip of Sc_2 and R_2 in alignment; inner end of cell 1st M_2 strongly arcuated; veins beyond cell 1st M_2 elongate; m-cu about one-third its length beyond the fork of M.

Abdominal tergites dark brown, the sternites somewhat paler. Male hypopygium (Plate 2, fig. 26) with the tergite, *9t*, transverse, each low lateral lobe with about four long setæ; what appears to be the median ventral portion of the tergite is produced into a rectangular plate that is densely set with short even setæ. Basistyle, *b*, long, the ventromesal lobe relatively small. Dorsal dististyle apparently represented by a simple nearly straight rod, the tip acute. Ventral dististyle, *vd*, very small, the main body of the organ about the size of the lobe of the basistyle, with a few long setæ, the mesal apical portion produced into a small slender spinous beak; rostral prolongation very large and flattened, without evident armature other than setæ.

Habitat.—Formosa.

Holotype, male, Shinten, April 15, 1928 (*S. Issiki*).

LIMONIA (DISCOBOLA) MARGARITA (Alexander).

Discobola margarita ALEXANDER, Philip. Journ. Sci. 24 (1924) 539–540.

Known hitherto only from Karafuto and Hokkaido, northern Japan. A female, Mount Rantaizan, Formosa, altitude 7,000 feet, June 3, 1927 (*S. Issiki*).

LIMONIA (DISCOBOLA) ARGUS (Say).

Limnobia argus SAY, Long's Exped., Append. (1824) 358.

A wide-ranging species in northern North America and northeastern Asia, not before recorded from south of the main island of Japan. A female, Shorei, Formosa, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

LIMONIA (DICRANOMYIA) AURITA sp. nov.

Belongs to the *morio* group; size large (wing, male, over 7 millimeters); Sc_1 long; male hypopygium with the caudolateral angles of the tergite produced into long slender arms; ventromesal lobe of basistyle long, boomerang-shaped; outer dististyle bifid at apex.

Male.—Length, about 7.5 millimeters; wing, 7.4.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval to long-oval. Head black, the frons more silvery pruinose.

Mesonotum polished black, the median region of the scutum, the scutellum, and the cephalic portion of the postnotal mediotergite slightly more pruinose. Pleura black, with a gray pruinescence. Halteres yellow, the knobs brownish black. Legs with the fore and middle coxæ polished black, the apices more yellowish; posterior coxæ obscure yellow, trochanters yellow; remainder of legs black, the femora yellow basally, narrowest on the fore femora where about the basal fourth is included, least evident on the posterior femora where only the tips are darkened. Wings (Plate 1, fig. 7) with a brownish tinge, the oval stigma darker brown; veins dark brown. Venation: Sc short, Sc_1 ending shortly before the origin of Rs, Sc_2 far before the tip, Sc_1 alone being nearly as long as Rs; free tip of Sc_2 shortly proximad of the level of R_2; m-cu shortly before the fork of M, subequal to the distal section of Cu_1; vein 2d A relatively long.

Abdomen black, the caudal margins of the basal sternites obscure yellow; hypopygium chiefly dark. Male hypopygium (Plate 2, fig. 27) with the ninth tergite, *9t*, transverse, the outer lateral angles produced caudad and slightly mesad into long slender arms that are tipped with short setæ. Basistyle, *b*, relatively small, the ventromesal lobe large and of very unusual form, being more or less boomerang-shaped, the outer margin at the angulation with a few longer setæ; a small tubercle on mesal face of basistyle toward apex; a conspicuous pencil of long setæ that are curved at tips, located near base of style. Outer dististyle, *od*, bifid and blackened at apex. Inner dististyle, *id*, fleshy, irregular in shape, the rostral prolongation very stout, with a single pale spine. Gonapophyses with the mesal apical angle slender.

Habitat.—Formosa.

Holotype, male, Ritozan, altitude 5,000 feet, August 1, 1928 (*S. Issiki*).

Limonia (*D.*) *aurita* is very distinct from the other regional members of the *morio* group. The peculiar characters of the basistyle and outer dististyle of the male hypopygium are suggested by *L.* (*D.*) *pseudomorio* Alexander (Japan).

LIMONIA (DICRANOMYIA) MONTIUM sp. nov.

General coloration brownish gray, the pronotum and mesonotal præscutum with a median dark brown stripe; antennæ entirely black; wings grayish, the oval stigma darker; Sc_1 ending

shortly beyond, Sc_2 nearly opposite, the origin of Rs; cell 1st M_2 relatively large; m-cu at the fork of M; male hypopygium with a single spine on the rostral prolongation of the ventral dististyle.

Male.—Length, about 6.5 millimeters; wing, 8.2.

Rostrum black, sparsely pruinose; palpi black. Antennæ black throughout; flagellar segments subglobular, passing into oval, the terminal segment longer than the penultimate; segments clothed with a dense white pubescence. Head grayish brown; anterior vertex of moderate width, with an impressed median line.

Pronotum gray, black medially. Mesonotal præscutum brownish gray with a median dark brown stripe that is slightly constricted before midlength, somewhat wider behind; posterior sclerites of the mesonotum dark gray, the centers of the scutal lobes dark brown. Pleura dark brown, heavily pruinose. Halteres yellow, the knobs weakly infuscated. Legs with the fore and middle coxæ dark, pruinose; posterior coxæ and all trochanters yellow; femora obscure brownish yellow at base, passing into dark brown at tips; remainder of legs black. Wings (Plate 1, fig. 8) with a grayish tinge, the oval stigma darker; veins dark brown, with long conspicuous black macrotrichia. Venation: Sc_1 ending shortly beyond the origin of Rs, Sc_2 immediately before this origin; Rs about two and one-half times the more-arcuated basal section of R_{4+5}; free tip of Sc_2 and R_2 in approximate alignment; cell 1st M_2 large, longer than the veins beyond it; basal section of M_3 arcuated to feebly angulated; m-cu at fork of M.

Abdomen brownish black, sparsely pruinose. Male hypopygium (Plate 2, fig. 28) with the ninth tergite, *9t*, transverse, the caudal margin gently emarginate, the lateral lobes low. Basistyle, *b*, relatively small, the ventromesal lobe large, obtuse. Outer dististyle, *od*, only moderately curved, the tip suddenly narrowed into a slightly decurved black point. Ventral dististyle, *id*, large and fleshy, the rostral prolongation flattened, the tip twisted and pendulous; a single rostral spine of moderate size. Gonapophyses, *g*, with the mesal apical lobe stout, its lateral margin microscopically serrulate.

Habitat.—Formosa.

Holotype, male, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

LIMONIA (ALEXANDRIARIA) ATAYAL sp. nov.

General coloration brown; præscutum obscure yellow with three brown stripes, the lateral stripes broad, reaching the lateral margins or nearly so; wings with a strong brownish suffusion; Sc long, Sc_1 ending almost opposite the origin of Rs, Sc_2 far from its tip; Rs longer than the basal section of R_{4+5}

Female.—Length, about 4.2 millimeters; wing, 5.

Rostrum and palpi black. Antennæ black throughout. Head dark brown.

Mesonotal præscutum obscure brownish yellow, with three brown stripes, the median stripe entire; lateral stripes broad and diffuse; humeral region of sclerite brighter yellow; scutal lobes dark brown, the median area and disk of scutellum paler; remainder of mesonotum dark brown. Pleura obscure yellow, striped longitudinally with dark brown, including the ventral anepisternum and the ventral sternopleurite. Halteres infuscated, the base of the stem narrowly obscure yellow. Legs with the fore coxæ infuscated, the remaining coxæ and trochanters obscure yellow; remainder of legs broken. Wings (Plate 1, fig. 9) with a strong brown suffusion, the oval stigma very slightly darker; veins dark brown. Venation: Sc unusually long, Sc_1 ending just before the origin of Rs, Sc_2 far from its tip; Rs longer than the basal section of R_{4+5}; free tip of Sc_2 and R_2 in alignment, both pale; m-cu at fork of M, longer than the distal section of Cu_1.

Abdominal tergites dark brown; sternites paler brownish yellow. Ovipositor with the tergal valves long and straight, the tips obtuse.

Habitat.—Formosa.

Holotype, female, Shinten, April 15, 1928 (*S. Issiki*).

ORIMARGA FUSCIVENOSA sp. nov.

General coloration of head and thorax dark plumbeous; halteres and legs dark; wings with a faint brownish tinge, the veins brownish black, very conspicuous; R_2 and R_{1+2} subequal; basal section of R_{4+5} angulated before midlength.

Male.—Length, about 5 millimeters; wing, 5.

Rostrum and palpi black. Antennæ black throughout. Head dark plumbeous gray.

Mesonotum and pleura entirely dark plumbeous gray. Halteres infuscated. Legs with the coxæ and trochanters dark brown; remainder of legs black. Wings (Plate 1, fig. 10) with a faint brownish tinge, the veins brownish black, very conspicuous; wing apex in radial field narrowly margined with brown;

costal vein incrassated; costal fringe relatively long and conspicuous. Macrotrichia of medial field beyond cord long and conspicuous. Venation: Sc_1 ending about opposite midlength of Rs, Sc_2 near its tip; free tip of Sc_2 nearly three times its length before R_2; R_2 subequal to R_{1+2}; basal section of R_{4+5} angulated and weakly spurred before midlength; r-m distal of level of R_2; petiole of cell M_3 short; m-cu about opposite one-fifth the length of Rs; vein 2d A produced, the cell narrowed and acute at outer end.

Abdominal tergites dark brown, the sternites a little paler; hypopygium black.

Habitat.—Formosa.

Holotype, male, Shinten, April 15, 1928 (*S. Issiki*).

Orimarga fuscivenosa is most closely allied to *O. taiwanensis* Alexander, likewise from Formosa, differing in the uniform dark plumbeous gray coloration, including the thoracic pleura, and the very dark wing veins, which are provided with long conspicuous macrotrichia. The details of venation are similarly distinct, including the position of Sc_2, the distinctness of the free tip of Sc_2, the longer Rs, with cell R_1 relatively longer and narrower, and the more-pointed 2d anal cell.

Genus THAUMASTOPTERA Mik

Thaumastoptera MIK, Verh. zool.-bot. Ges. Wien 16 (1866) 302.

The genus *Thaumastoptera* was proposed for the single species, *calceata* Mik, now known to be widely distributed in Europe. The only other described species are the Oligocene *T. electra* Alexander, from the Baltic amber, and *T. undulata* (Cockerell and Haines), from the Gurnet Bay deposits. It is thus a matter of great interest to record a species of the genus from the high mountains of Formosa. The presence of three supernumerary crossveins in the wings of the new species requires the formation of a new subgeneric group that is described below as *Taiwanita.* This venational condition would appear closely to parallel that found in *Limonia* and its subgenus *Discobola* Osten Sacken. The supernumerary and other transverse elements in the wing of *Taiwanita* (Plate 1, fig. 11) form an irregular cordlike arrangement lying proximad of the true cord, these crossveins and deflections being Sc_2, the basal section of Rs, the supernumerary crossvein in cell R, the m-cu crossvein, and the supernumerary crossveins in cells Cu and 1st A. It should be noted that a supernumerary crossvein in cell Cu is not known in any other crane fly. The members of the genus *Thaumastoptera* are peculiar in the

habits of the larvæ, which live in cold springs and construct a portable case.[2]

Subgenus TAIWANITA novum

Characters as in typical *Thaumastoptera,* differing especially in the venation. Supernumerary crossveins in cells R, Cu, and 1st A.

Type of the subgenus, *Thaumastoptera* (*Taiwanita*) *issikiana* sp. nov. (Eastern Palæarctic Region).

THAUMASTOPTERA (TAIWANITA) ISSIKIANA sp. nov.

General coloration grayish white; antennæ with the basal segments infuscated, the outer segments paling to yellow; legs yellow, the femoral tips conspicuously blackened; wings pale yellow, variegated with brown areas on the crossveins and deflections and numerous gray dots in the cells; supernumerary crossveins in cell R, Cu, and 1st A.

Male.—Length, about 4 millimeters; wing, 5.

Rostrum obscure brownish yellow; maxillary palpi black. Antennæ with the scapal segments brownish testaceous; basal segments of flagellum infuscated, the outer segments passing into yellow; basal flagellar segments oval, the outer segments more elongated; all segments with long powerful setæ that exceed the segments in length. Head pale grayish white.

Mesonotum pale grayish white, without markings, the lateral portions of the præscutum more yellowish; posterior mediotergite a little infuscated. Pleura pale yellow, with a dusky cloud on the dorsopleural region. Halteres white. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips conspicuously blackened, preceded by a narrow more whitish ring; remainder of legs pale yellow. Wings (Plate 1, fig. 11) pale yellow, handsomely variegated with dark brown seams on the veins and numerous pale gray dots in the cells; the darker seams include the arculus, origin of Rs, all crossveins and deflections of veins, tips of Sc_1, and all longitudinal veins; the gray dots occur in all cells; veins pale yellow, darker in the seamed areas. Venation: Sc long, Sc_1 ending about opposite three-fourths the length of Rs, Sc_2 just before the origin of the latter; Rs angulated, with a supernumerary crossvein at the angulation, connecting posteriorly with M; R_2 in transverse alignment with R_{1+2}; inner end of cell R_3 lying a little proximad of cell 1st M_2; m-cu nearly twice its length before the fork of M; a supernumerary

[2] Lenz, Fr., Thaumasoptera calceata Mik, eine gehäusetragente Tipulidenlarve, Archiv für Naturgeschichte **85**, Abt. A., Heft 4 for 1919 (1920) 114–136, figs. 1–28.

crossvein in cell Cu at near midlength, this completely traversing vein Cu_2; a supernumerary crossvein in cell 1st A, connecting with vein 2d at near two-thirds its length.

Abdomen pale yellow, the pleural region more darkened. Male hypopygium (Plate 2, fig. 29) with the dististyle, *d,* single, as in the genus, appearing as a flattened blade, the apex produced into a slender acute point, the outer margin with a small appressed tooth.

Habitat.—Formosa.

Holotype, male, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

HELIUS (HELIUS) NAWAIANUS sp. nov.

Mesonotum reddish yellow, the cephalic half of the præscutum with a dark brown median stripe; antennæ (male) relatively long, about twice as long as the combined head and rostrum; abdomen dark brown, the hypopygium yellow; male hypopygium with the outer dististyle terminating in two obtuse spines, the outer margin with three long powerful setæ.

Male.—Length, about 6.5 millimeters; wing, 7.5.

Female.—Length, about 8.5 millimeters; wing, 7.8.

Rostrum and palpi dark brown. Antennæ relatively elongated, as in *H. nipponensis,* about twice as long as the combined head and rostrum, dark brown; flagellar segments cylindrical, with a dense white pubescence and short scattered black verticils. Head gray.

Pronotum dark brown medially, paler laterally. Mesonotum reddish yellow, the cephalic half of the præscutum with a dark brown median stripe, the remainder of the notum unmarked. Pleura reddish yellow. Halteres pale. Legs with the coxæ and trochanters concolorous with the pleura; femora obscure yellow, the tips narrowly infuscated; tibiæ brownish yellow, the tips vaguely darkened; tarsi passing into brownish black beyond bases. Wings with a very pale brownish tinge, the stigma only slightly darker; veins dark brown. Venation: Sc_1 ending just before the fork of Rs, Sc_2 at its tip; Rs nearly straight; cell 1st M_2 large, the proximal end wider; m-cu close to the fork of M.

Abdomen dark brown, the basal sternites a very little paler; hypopygium and subterminal segments yellow. Male hypopygium with the outer dististyle, *od* (Plate 2, fig. 30), ending in two subequal blackened knobs, or obtuse spines, not produced into a long apical spine as in *H. nipponensis* (Plate 2, fig. 31); on outer margin before apex with three long powerful setæ that

are entirely lacking in *nipponensis*, *brevioricornis*, and allied forms.

Habitat.—Japan (Honshiu).

Holotype, male, Ōi, Gifu, June 6, 1923 (*R. Takahashi*). Allotopotype, female.

Helius nawaianus is named in honor of the great pioneer entomologist of Japan. In *H. nipponensis* Alexander the præscutum has three distinct stripes, the centers of the scutal lobes are blackened, and the abdomen is much paler.

HELIUS (HELIUS) LILIPUTANUS sp. nov.

Size very small (wing, male, under 3.5 millimeters); rostrum elongated; thorax ocherous yellow; wings grayish subhyaline, without a distinct stigma; Sc short; cell M_2 open by the atrophy of m; abdominal segments conspicuously bicolorous.

Male.—Length, excluding rostrum, about 3 mllimeters; wing, 3.2; rostrum, about 1.1.

Rostrum elongated, dark brown, exceeding the combined head and thorax. Antennæ brownish black, with only fifteen apparent segments; first flagellar segment large; terminal segment reduced to a tiny button; verticils long and conspicuous, much exceeding the segments, more elongate on the outer segments. Head pale, the anterior vertex narrow.

Thorax pale ocherous yellow, the mesonotum somewhat darker behind; sternopleurite slightly infuscated. Halteres dark brown, the base of the stem narrowly pale. Legs with the coxæ and trochanters pale yellow, those of the fore legs somewhat darker; remainder of legs broken. Wings (Plate 1, fig. 12) grayish subhyaline, the stigma scarcely darkened; wing margin in radial field narrowly and vaguely seamed with brown; veins pale brown. Venation: Sc short, Sc_1 ending about opposite midlength of the short Rs, Sc_2 at its tip; veins R_3 and R_{4+5} at wing margin widely divergent, cell R_3 being unusually wide; cell M_2 open by the atrophy of m; m-cu nearly its own length beyond the fork of M, longer than the distal section of Cu_1; cell 2d A narrow.

Abdominal segments conspicuously bicolorous, the bases broadly obscure yellow, the slightly narrower apical portions dark brown; subterminal segments uniformly darkened, forming a ring; hypopygium chiefly pale. Male hypopygium (Plate 2, fig. 32) with a conspicuous interbasal rod, *i*. Outer dististyle, *od*, slender, bifid at apex, the outer tooth broken near base in the unique type.

Habitat.—Formosa.

Holotype, male, Michishita, altitude 4,000 feet, July 31, 1928 (*S. Issiki*).

The structure of the outer dististyle is generally similar to *Taiwanina pandoxa* Alexander, and it is very possible that the latter genus is more correctly placed near *Helius* despite the reduced palpi, peculiar antennal structure, and shape of the thorax.

HEXATOMINI

ULA SUPERELEGANS sp. nov.

General coloration black, pruinose; antennæ elongate; wings yellowish, with a heavy brown pattern, including a large area surrounding Sc_2; stigma yellow, both ends darkened; abdominal tergites black, the caudal margins narrowly ringed with obscure yellow; sternites dark, the incisures broadly yellow.

Female.—Length, about 6.5 to 7 millimeters; wing, 7 to 8.

Rostrum and palpi black. Antennæ elongate, in female, if bent backward, extending to some distance beyond the wing root; scapal segments obscure yellow, the flagellum black; flagellar segments fusiform, with long conspicuous verticils. Head brownish gray.

Mesonotum black with a conspicuous brownish yellow pollen, the scutellum and postnotum somewhat more pruinose. Pleura black, sparsely pruinose; dorsopleural membrane dusky. Halteres dusky, the basal half of the stem yellow, the knobs more infuscated. Legs with the coxæ brownish yellow, paler apically; trochanters obscure brownish yellow; femora brownish black, the bases obscure yellow, more broadly so on the posterior legs; tibiæ yellowish brown to brownish black, the tips still darker; tarsi passing into black. Wings with a yellowish color, variegated with a very heavy brown pattern, including extensive seams at Sc_2, origin of Rs, along the cord from the costa at Sc_1 to Cu; outer end of stigma surrounding R_2 and R_{1+2}; outer end of cell 1st M_2; narrower dusky clouds at wing apex, as marginal areas at ends of radial veins and as a conspicuous seam for almost the whole length of the distal section of Cu_1; stigma chiefly yellow, brighter than the ground color; veins dark brown. The holotype has an additional small linear dark seam in cell 1st A. Macrotrichia of cells nearly lacking in the proximal ends of the basal cells, including nearly the basal half of 2d A. Venation: Rs angulated at origin, forking at r-m; m-cu nearly in alignment with r-m.

Abdominal tergites black, the segments narrowly ringed caudally with obscure testaceous yellow; sternites similar, the inci-

sures broadly and conspicuously obscure yellow, this including both the bases and apices of the segments; subterminal segments more uniformly blackened. Ovipositor with the base of the genital segment infuscated, the remainder brownish yellow; tergal valves strongly upcurved to the very acute tips, the dorsal margin at base with a low obtuse darkened tooth.

Habitat.—Formosa.

Holotype, female, Shōri, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*). Paratopotype, female.

Ula superelegans sp. nov. and *U. fuscistigma* sp. nov. are distinct from the two species known from northern Japan, *Ula perelegans* Alexander and *U. cincta* Alexander.

ULA FUSCISTIGMA sp. nov.

General coloration black, pruinose; antennæ elongate; wings grayish, the stigma uniformly brown; large subcircular brown clouds at origin of Rs and on anterior cord; abdomen uniformly darkened.

Female.—Length, about 7 millimeters; wing, 7.2.

Rostrum and palpi black. Antennæ (female) elongate; scape dark brown, the flagellum black. Head dark gray.

Thorax black, the mesonotum sparsely pruinose, the scutellum and postnotum more heavily so. Pleura conspicuously pruinose, especially the ventral pleurites; dorso pleural region dark. Halteres pale, the knobs dark brown. Legs with the coxæ dark brown, the trochanters more brownish yellow; femora brownish yellow, passing into black; remainder of legs black. Wings (Plate 1, fig. 13) grayish, the stigma uniformly darkened; conspicuous subcircular brown clouds at origin of Rs and on anterior cord; narrower seams on posterior cord and outer end of cell 1st M_2; a tiny brown seam on Sc_2; veins dark brown. Macrotrichia of cells lacking only at extreme wing base, including about the basal third of cell 2d A. Venation: Rs forking just beyond r-m; R_{1+2} a trifle longer than R_2 alone; cell 1st M_2 relatively small.

Abdominal tergites black, the sternites a little paler, the pleural membrane dark; ovipositor yellowish horn-color, the tergal valves relatively broad, upcurved to the acute tips.

Habitat.—Formosa.

Holotype, female, Shōri, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

PSEUDOLIMNOPHILA AUTUMNALIS sp. nov.

General coloration gray, the præscutum with four narrow brown stripes; antennæ black, the base of the first flagellar seg-

ment yellow; legs chiefly brown, the tarsi passing into black; wings with a grayish brown suffusion, the pearcular and costal regions more yellowish; stigma and a vague pattern on the disk darker; distal section of Cu_1 straight; male hypopygium with the ædeagus short.

Male.—Length, about 8 millimeters; wing, 9.3.

Female.—Length, about 7 millimeters; wing, 8.2.

Rostrum brown, the palpi darker brown. Antennæ (male) relatively short, if bent backward, extending to just beyond the wing root; antennæ black, the basal third of the first flagellar segment yellow; flagellar segments subcylindrical, with verticils that exceed the segments. Head brownish gray, clearer gray in front.

Pronotum gray, the lateral portions of the scutellum obscure yellow. Mesonotal præscutum gray with four brown stripes, the intermediate pair separated by a capillary gray line; pseudosutural foveæ small, black; no tuberculate pits; remainder of mesonotum gray, the scutal lobes variegated with brown. Pleura gray. Halteres dusky, the base of the stem narrowly pale; in the paratype, the apices of the knobs slightly paler. Legs with the coxæ brownish gray basally, the apices pale; trochanters obscure yellow, margined with brown; femora brownish yellow, paler basally, the tips passing into dark brown; tibiæ and tarsi dark brown, the latter passing into black. Wings (Plate 1, fig. 14) with a grayish brown suffusion, the prearcular and costal regions more yellowish; stigma darker; very vague and diffuse clouds at origin of Rs, along cord and outer end of cell 1st M_2; axillary region darkened; veins dark brown. Macrotrichia of veins unusually long and conspicuous; costal fringe short in both sexes. Venation: Sc_1 ending about opposite r-m, Sc_2 at its tip; Rs angulated at origin; R_{2+3+4} relatively long, gently arcuated, longer than R_{2+3}; R_2 subequal to R_{1+2}; cell 1st M_2 short, m-cu at near two-thirds its length; cell M_1 deep, its petiole subequal to or shorter than m-cu; distal section of Cu_1 straight; vein 2d A long, gently sinuous.

Abdominal tergites dark brown, the central portion more yellowish to produce a more or less distinct dorsomedian vitta; subterminal segments and hypopgium entirely blackened; sternites infuscated, the intermediate segments with a large yellowish triangle on posterior half, the point directed cephalad. Male hypopygium (Plate 2, fig. 33) with the tergite, *9t,* deeply notched. Basistyle short and broad. Outer dististyle, *od,* narrowed to the simple apex, the outer surface setiferous. Inner

dististyle with the basal half enlarged, the outer margin with numerous conspicuous erect setæ, the apical point elongate. Ædeagus short. What appears to represent an interbasal process appears as a trispinous structure, as figured.

Habitat.—Formosa.

Holotype, male, Mareppa, altitude 6,000 feet, October 25, 1928 (*S. Issiki*). Allotype, female, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*). Paratopotype, male.

The only similar grayish *Pseudolimnophila* from this general region is *P. horii* Alexander (Japan), which differs in the general coloration of the body and wings, the yellow halteres, the venation, as the strongly curved distal section of Cu_1, and the structure of the male hypopygium.

TROGLOPHILA RITOZANENSIS sp. nov.

General coloration brown, the humeral region of the præscutum more yellowish; head brownish gray; wings with a brown tinge; Rs and R_{2+3+4} subequal, the former slightly more arcuated; m-cu just before the fork of M.

Female.—Length, about 3.5 millimeters; wing, 4.6.

Rostrum and palpi pale brown. Antennæ (female) of moderate length only, if bent backward extending about to the wing root; antennæ dark brown. Head brownish gray.

Mesonotum brown, the humeral region of præscutum more yellowish. Pleura brown. Halteres dusky, the base of the stem narrowly yellow. Legs with the coxæ brownish testaceous, the posterior coxæ paler; remainder of legs pale brown, the setæ dark. Wings (Plate 1, fig. 15) with a faint brownish tinge, the stigma scarcely darker; veins and macrotrichia dark brown. Venation: Sc relatively long, Sc_1 ending just beyond r-m, Sc_2 a short distance from the tip of Sc_1; Rs relatively short, arcuated, subequal to or slightly longer than the more gently arcuated R_{2+3+4}; R_2 very faint, R_{2+3} nearly as long as R_{1+2}, the latter less than one-half $R_1 + Sc_2$; m-cu shortly before the fork of M.

Abdomen uniform brown, the sternites a little paler. Ovipositor with the valves fleshy, terminating in a slender pale setoid structure.

The left wing of the type has cell M_1 present as a small areole that is less than one-fifth the length of the petiole.

Habitat.—Formosa.

Holotype, female, Ritozan, altitude 5,000 feet, August 1, 1928 (*S. Issiki*).

Troglophila ritozanensis is most closely allied to *T. alticola* (Edwards), of Borneo. It cannot be stated whether the condi-

tion of having cell M_1 preserved is normal, the venation of the two wings of the type being conspicuously unlike.

LIMNOPHILA (TRICHOLIMNOPHILA) CÆSIELLA sp. nov.

Male.—Length, 7.5 to 8 millimeters; wing, 7 to 7.5.

Closely allied and generally similar to *L.* (*T.*) *pilifer* Alexander, differing in the slightly longer antennæ and details of coloration.

Rostrum and head light gray. Antennæ longer than in *L. pilifer,* if bent backward extending approximately to the root of the halteres, pale brown. Mesothorax entirely gray, the præscutal stripes scarcely evident, the pruinosity including the entire præscutum. Male hypopygium with the lobes of the tergite long and more expanded at apices, the notch inclosed thus more or less narrowed at outer end.

Habitat.—Japan (Kiushiu).

Holotype, male, Hirao Hill, near Fukuoka, April 5, 1924 (*H. Hori*). Paratopotypes, 1 male, with type; 2 males, Fukuoka, April 13, 1924 (*H. Hori*).

The specimens of the rather extensive series of *L. pilifer* before me all show the cephalic portion of the median præscutal stripe highly polished and shiny black.

LIMNOPHILA RANTAIZANA sp. nov.

General coloration brownish yellow; antennæ (male) short; wings brownish yellow, with a weak dark pattern; macrotrichia of veins long and conspicuous; inner ends of cells R_4, R_5, and 1st M_2 in oblique alignment; male hypopygium with the median region of the tergite produced caudad into a bilobed rod.

Male.—Length, about 5.5 millimeters; wing, 6.8.

Rostrum yellow; palpi dark brown. Antennæ (male) short, if bent backward extending to opposite or just beyond the wing root; pale brownish yellow, the outer segments somewhat darker; flagellar segments long-oval, with a dense pale pubescence and verticils that slightly exceed the segments. Head grayish ocherous, the center of the broad vertex a little darkened.

General coloration of the thorax brownish yellow, subnitidous, without evident markings; pseudosutural foveæ concolorous with the præscutum; no tuberculate pits. Pleura testaceous yellow. Halteres relatively long and slender, obscure yellow, the knobs more darkened. Legs with the coxæ and trochanters pale yellow; femora brownish yellow, a little darkened outwardly; tibiæ and tarsi pale brown, the outer tarsal segments somewhat darker; legs conspicuously hairy. Wings (Plate 1, fig. 16) with a strong

brownish yellow tinge; stigma oval, darker brown, very vague and restricted; dark seams on anterior cord; veins brown, the macrotrichia long and conspicuous. Venation: Sc_1 ending just before the fork of Rs, Sc_2 a short distance from its tip; Rs long and gently arcuated; R_{2+3+4} short, less than the basal section of R_5 R_2 pale, R_{3+2} subequal to R_{1+2}; inner ends of cells R_4, R_5, and 1st M_2 in oblique alignment, the last-named most proximad; cell M_1 deep, about one-half longer than its petiole; cell 1st M_2 small, m-cu beyond midlength; anterior arculus present.

Abdomen pale brown, the sternites somewhat paler. Male hypopygium (Plate 2, fig. 34) with the tergite, *9t*, produced medially into a narrow rod, the apex bilobed. Basistyle, *b*, relatively short and stout, the interbasal process small, pale, appearing as an obtuse blade. Outer dististyle, *od*, a narrow rod, the apex unequally bidentate. Inner dististyle, *id*, very small, pale, setiferous, the lower or cephalic margin before midlength bearing two or three more powerful setæ from tuberculate bases. Ædeagus long and slender, pale, the apex apparently broken in the unique type. Gonapophyses, *g*, appearing as slender hooks, narrowed to the acute tips.

Habitat.—Formosa.

Holotype, male, Rantaizan, altitude 6,000 to 7,000 feet, May 21, 1928 (*S. Issiki*).

The structure of the ninth tergite and outer dististyle somewhat suggests members of the subgenus *Tricholimnophila*, but in other respects there is little in common between the groups.

PILARIA FORMOSICOLA sp. nov.

General coloration shiny dark brown, the pleura more brownish yellow; wings with a strong brown tinge, the stigma darker; R_2 just before the fork of R_{3+4}; cell M_1 present; m-cu at about two-thirds the length of cell 1st M_2; abdominal tergites uniformly blackened, the sternites yellowish brown.

Female.—Length, about 9 millimeters; wing, 8.5.

Rostrum and palpi dark brown. Antennæ (female) relatively elongate, if bent backward extending about to the root of the halteres; antennæ black throughout; flagellar segments elongate, with long conspicuous verticils, the dorsal, unilaterally arranged series much exceeding the segments in length. Head dark brown.

Mesonotum shiny dark brown, the pleura more brownish yellow. Halteres relatively elongate, dusky, especially the knobs. Legs with the coxæ and trochanters yellow; remainder of legs black, the femoral bases vaguely brightened. Wings (Plate 1,

fig. 17) with a strong brownish tinge, the oval stigma darker brown; veins dark brown. Venation: Sc_1 ending some distance before the fork of Rs, Sc_2 at its tip; Rs angulated and weakly spurred at origin; R_2 oblique, just before the fork of R_{3+4}; inner ends of cells R_4, R_5, and 1st M_2 in oblique alignment; cell M_1 longer than its petiole; m-cu at about two-thirds the length of cell 1st M_2; vein 2d A elongate.

Abdominal tergites black, the sternites yellowish brown. Ovipositor with the valves very elongate; tergal valves dark basally, the tips paling to yellow; sternal valves yellow, the bases more narrowly blackened.

Habitat.—Formosa.

Holotype, female, Sorempi, near Giran, altitude 1,500 feet, November 4, 1928 (*S. Issiki*).

ERIOPTERINI

CLADURA DECEM-NOTATA Alexander.

Cladura decem-notata ALEXANDER, Ann. Ent. Soc. America 17 (1924) 436–437.

This interesting species was described from various stations in Kiushiu, Japan. In the present series of Tipulidæ from Professor Issiki were a few males of what appears to be the same species from Shorei, Formosa, altitude 7,000 to 8,000 feet, October 25, 1928. The type series was represented only by females, while the present material includes only males. The Formosan material shows slight differences, chiefly in the size and intensity of the black body markings, and it is possible that they may represent a distinct but closely allied species.

NEOLIMNOPHILA ALTICOLA sp. nov.

General coloration gray; mesonotal præscutum with the cephalic ends of the intermediate and lateral stripes shiny polished black; legs black; wings grayish, the prearcular region yellowish; stigma a little darker than the ground color; male hypopygium with the basistyle having a single curved spinous bristle near base.

Male.—Length, 6.5 to 7 millimeters; wing, 7 to 8.

Female.—Length, 7 to 7.5 millimeters; wing, 7 to 8.

Rostrum dark gray; palpi black. Antennæ black throughout; fusion segment elongate-conical, composed of four subsegments, the sutures between indicated; segments beyond the fusion subcylindrical, gradually increasing in length to the antepenultimate, the remainder shorter. Head brownish gray, the front and restricted posterior orbits clearer gray.

Mesonotal præscutum yellowish gray with four brown stripes, the cephalic end of the intermediate pair and of each lateral stripe polished black; posterior sclerites of mesonotum clearer gray. Pleura gray. Halteres pale, the knobs weakly dusky. Legs with the coxæ gray; trochanters yellowish brown; remainder of legs black, the femoral bases very narrowly and restrictedly obscure yellow. Wings (Plate 1, fig. 18) with a grayish suffusion, the oval stigma only a little darker than the ground color; prearcular region conspicuously yellow; veins brown. Venation: Sc_1 ending about opposite the fork of Rs, Sc_2 at its tip; R_{2+3+4} elongate; R_2 variable in position, in most instances about its own length beyond the fork of R_{2+3+4}; cell 1st M_2 small; cell M_1 subequal to or slightly longer than its petiole; m-cu variable in position, from close to the fork of M to opposite two-fifths the length of cell 1st M_2.

Abdomen, including the hypopygium, black, sparsely pruinose. Male hypopygium (Plate 2, fig. 35) with the basistyle, *b*, long and slender, at base with a single long curved spinous bristle. Outer dististyle, *od*, long and slender, curved, the apex narrowed and arched, the outer margin with appressed denticles that are somewhat more erect and conspicuous just before the apex. Inner dististyle with conspicuous setæ.

Habitat.—Formosa.

Holotype, male, Shirasetsu, altitude 6,000 feet, October 24, 1928 (*S. Issiki*). Allotype, female, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*). Paratopotypes, 5 males, 1 female; paratypes, 1 male, 1 female, with the allotype.

Neolimnophila alticola is amply distinct from the other species known from eastern and southern Asia; namely, *N. ultima* (Osten Sacken), *N. genitalis* (Brunetti) (equals *simplex* Brunetti), and *N. fuscinervis* Edwards.

LIPSOTHRIX PLUTO sp. nov.

General coloration shiny coal-black; antennæ (male) elongate; legs black, only the extreme bases of the femora obscure yellow; wings with a strong dusky tinge, the oval stigma darker.

Male.—Length, about 7.5 millimeters; wing, 8.5; antennæ, about 3.3.

Rostrum and palpi black. Antennæ (male) elongate, black throughout; flagellar segments cylindrical with verticils that are shorter than the segments; flagellar segments gradually decreasing in length outwardly, the terminal segment abruptly smaller, subglobular. Head dull black.

Thorax shiny coal-black, the anterior lateral pretergites very restrictedly obscure yellow; dorsopleural membrane black. Halteres dirty white, the knobs infumed. Legs with the coxæ and trochanters yellow; femora black, the extreme bases obscure yellow; remainder of legs black. Wings (Plate 1, fig. 19) with a strong dusky tinge, the oval stigma darker brown; veins black, with long conspicuous macrotrichia, especially on the veins beyond origin of Rs. Venation: Sc_1 ending about opposite one-third the length of R_{2+3+4}, Sc_2 at its tip; Rs long, nearly straight; R_{2+3+4} a little shorter than R_{2+3}; R_2 equal to R_{1+2}; m-cu about one-half its length beyond the fork of M.

Abdomen black, the hypopygium a very little paler. Male hypopygium with the basistyles relatively stout, the interbasal process pale yellow, bladelike, narrowed to the acute tip. Outer dististyle entirely blackened, the apical spine much larger than the subterminal appressed tooth. Inner dististyle more elongate, the distal half slender, tufted apically with long stout setæ.

Habitat.—Formosa.

Holotype, male, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

Lipsothrix pluto is a striking species of the genus, very distinct from the only other regional member of the group.

GNOPHOMYIA DEJECTA sp. nov.

General coloration plumbeous black; antennæ relatively elongate, flagellar segments cylindrical; halteres and legs dark brown; wings with a faint brown suffusion, the stigma scarcely darker; Rs in alignment with R_5; cell 1st M_2 relatively elongate, exceeding vein M_4 beyond it; m-cu shortly before midlength of the cell; male hypopygium with the tergite subquadrate, its caudal margin with a U-shaped emargination; outer dististyle a simple glabrous rod.

Male.—Length, about 5.5 millimeters; wing, 6.

Female.—Length, about 6.5 millimeters; wing, 7.

Rostrum and palpi black. Antennæ relatively elongate, black throughout; flagellar segments (male) cylindrical, the outer segments gradually decreasing in length, the terminal segment about two-thirds the penultimate; verticils shorter than the segments. Head brownish black.

Thorax plumbeous black, the posterior sclerites of the pleura somewhat paler; dorsopleural region paler; anterior lateral pretergites restrictedly light yellow. Halteres dark brown, the base of the stem narrowly paler. Legs dark brown. Wings (Plate 1, fig. 20) with a faint brown suffusion, the stigma

scarcely darker; veins dark brown. Macrotrichia of veins of moderate length only. Venation: Sc_1 ending just before R_2, Sc_2 about opposite one-third the length of R_{2+3+4}; Rs in alignment with R_5; r-m at fork of Rs; cell 1st M_2 relatively long exceeding vein M_4 beyond it, m-cu shortly before midlength.

Abdomen dark brown, the hypopygium black. Male hypopygium (Plate 2, fig. 36) small. Ninth tergite 9*t*, small, subquadrate, the caudal margin with a conspicuous U-shaped emargination, the sublateral lobes thus formed acute. Basistyle, *b*, with the mesal margin produced into a short acute black spine. Outer dististyle, *od*, a simple, slender, entirely glabrous rod arising from an expanded base. Inner dististyle shorter, strongly arcuated, the surface with several stout spinous setæ, the apex a little expanded, blackened, glabrous. Ovipositor with the tergal valves relatively short and high, the basal half wider, the distal half slightly upturned, narrowed to the subacute tip.

Habitat.—Formosa.

Holotype, male, Taihoku, April 20, 1922 (*K. Takeuchi*).

Allotype, female, Hokuto, near Taihoku, February 10, 1928 (*S. Issiki*).

Gnophomyia dejecta is allied to *G. orientalis* de Meijere, differing in the larger size and details of coloration.

GNOPHOMYIA BREVICELLULA Alexander.

Gnophomyia brevicellula ALEXANDER, Philip. Journ. Sci. 22 (1923) 472–473.

The type, a unique male, was taken at Tattaka, Formosa, altitude 7,400 feet, August 16, 1921, by Teiso Esaki. A second male specimen is now on hand, collected at Chikurin, Formosa, altitude 3,000 feet, July 3, 1928, by Syuti Issiki.

The wing venation has not been figured and is shown herewith (Plate 1, fig. 21). The male hypopygium exhibits a rather remarkable structure of what seems to be ninth tergite (Plate 2, fig. 37). This supposed tergite, 9*t*, appears as a somewhat lyriform structure, the long divergent arms being gradually widened to shortly before the tips, thence narrowed to the acute points. In the holotype, as figured, the arms are slightly shorter and broader than in the more recently discovered specimen. Outer dististyle, *od*, a long slender arm, the tip obtusely rounded. Inner dististyle, *id*, expanded at base, the curved apical portion with flattened peglike setæ.

TRENTEPOHLIA (MONGOMA) ATAYAL sp. nov.

Size small (wing, male, 5 millimeters); antennal verticils short; mesonotum dark brown, the præscutum brownish yellow with a conspicuous dark brown median stripe; legs pale; wings with a grayish tinge, almost unmarked except for the stigma and an apical clouding; apical fusion of Cu_1 and 1st A slight.

Male.—Length, about 5 millimeters; wing, 5.

Rostrum and palpi dark. Antennæ brown throughout, of moderate length; flagellar segments cylindrical, with short verticils. Head blackish gray, carinate medially.

Mesonotal præscutum brownish yellow, with a conspicuous dark brown median stripe that is slightly wider behind; scutum similarly pale, the centers of the lobes extensively dark brown; scutellum and postnotum dark brown. Pleura uniformly dark brown. Halteres short, dark brown, the base of the stem restrictedly pale. Legs with the fore coxæ darkened, the remaining coxæ paler; trochanters yellow; remainder of legs pale brownish yellow, without clearly defined pattern, the tarsi passing into darker; no especial armature on legs other than two elongate setæ at tips of femora. Wings (Plate 1, fig. 22) with a grayish tinge, the prearcular region and cells C and Sc more yellowish; stigma elongate-oval, brown; wing apex narrowly and diffusely darkened; restricted brown seams along vein Cu and in cell 1st A at angulation of vein 2d A; veins brown. Venation: Rs subequal to R_{2+3+4}; cell R_3 large; inner end of cell M_3 lying proximad of other cells beyond cell 1st M_2; m-cu at fork of M; fusion of Cu_1 and 1st A slight, about one-half m-cu; vein 2d A subangulate before midlength.

Abdomen brownish black, including the hypopygium, the central portions of the intermediate tergites paler.

Habitat.—Formosa.

Holotype, male, Inzan, near Giran, November 2, 1928 (*S. Issiki*).

Trentepohlia (*M.*) *atayal* is distinguished from allied small species of the subgenus by the combination of characters, as diagnosed above.

TRENTEPOHLIA (MONGOMA) TARSALBA sp. nov.

General coloration dark brown, the posterior sclerites of the mesonotum and the pleura paler; legs black, the tarsi chiefly snowy white; wings grayish, variegated with brown seams, including vein Cu and the fused portion of Cu_1 and 1st A; veins Cu_1 and 1st A extensively fused before margin.

Female.—Length, about 5.5 millimeters; wing, 5.2.

Rostrum and palpi dark, the tips of the labial palpi yellow. Antennæ black throughout. Head black.

Mesonotum dark brown, the lateral margins of the præscutum and posterior sclerites of the notum more testaceous. Pleura testaceous, the dorsal pleurites darker. Halteres short, dusky. Legs with the coxæ and trochanters concolorous with the pleura, the fore coxæ somewhat darker; femora and tibiæ black; basitarsi brown, paling to white at tips; remainder of tarsi snowy white, the terminal segment darkened. Wings (Plate 1, fig. 23) grayish, sparsely variegated with brown, including the elongate stigma; a longitudinal brown wash on vein Cu in cell M, beyond the fork of the vein continued along the fused Cu_1 + 1st A to the wing margin; axillary region somewhat darkened; wing apex a little suffused; veins brown. Venation: Rs longer than the basal section of R_5; R_{2+3+4} very long, exceeding R_4; R_2 longer than R_{3+4}; vein R_5 powerful, the medial veins beyond the fork of M weak and semievanescent; inner end of cell M_3 lying proximad of the others; fusion of Cu_1 and 1st A extensive, more than twice m-cu.

Abdomen black, the sternites somewhat paler. Ovipositor with relatively large and conspicuous valves, the tergal valves dark, strongly upcurved, the sternal valves high, yellow, dark at base.

Habitat.—Formosa.

Holotype, female, Giran, November 5, 1928 (*S. Issiki*).

The only described species of the subgenus *Mongoma* with a similar venation of the cubital and anal fields is *T.* (*M.*) *retracta* Edwards.

ORMOSIA SHOREANA sp. nov.

Size relatively large (wing, male, 6 millimeters); general coloration gray, the præscutum with a brown median stripe; femora obscure yellow with a broad brownish black subterminal ring; wings dusky, variegated with darker brown and pale areas; cell M_2 open by the atrophy of the basal section of M_3; vein 2d A strongly sinuous; male hypopygium with the dististyles subterminal in position, three in number, all simple.

Male.—Length, about 5 millimeters; wing, 6.

Rostrum and palpi brownish black. Antennæ of moderate length; basal segments pale brown; flagellum black, the incisures restrictedly pale; flagellar segments gradually decreasing in size outwardly, with long, unilaterally arranged verticils. Head dark gray.

Pronotum brownish gray, the lateral pretergites yellow. Mesonotal præscutum brownish gray, with a brown median stripe and less evident lateral stripes; scutum gray, the centers of the lobes variegated with darker; scutellum and postnotum heavily pruinose. Pleura gray. Halteres with the basal half of the stem yellow, the distal half infuscated, the knobs paling to obscure yellow. Legs with the coxæ gray; trochanters obscure yellow; femora obscure yellow, with a broad brownish black subterminal ring, the tips narrowly yellow; tibiæ black, the extreme bases pale; tarsi black. Wings (Plate 1, fig. 24) with a strong dusky suffusion, the costal and stigmal regions darker brown; extensive paler areas, as follows: Before and beyond the origin of Rs, the latter extending cephalad into cell Sc_1; outer end of cell R and across the fork of M into the adjoining cells; axillary region pale; veins brown. Venation: Sc_1 ending just beyond R_2, Sc_2 opposite one-fifth the length of Rs; R_2 a trifle longer than R_{2+3}; cell M_2 open by the atrophy of the basal section of M_3; m-cu a little less than its own length before the fork of M; vein 2d A very strongly sinuous.

Abdomen, including the hypopygium, black, more or less pruinose. Male hypopygium (Plate 2, fig. 38) with the ninth tergite, *9t*, apparently double as in this group of species, there being a paler and more fleshy structure beneath the true tergite, the latter profoundly bifid. Basistyle, *b*, produced slightly beyond the level of insertion of the dististyles. Dististyles, *d*, three, the outermost a glabrous earlike portion; longest style gently curved to the obtuse apex, the ventral margin with pale membrane set with tubercles; innermost style a slender curved rod, the tip acute or nearly so.

Habitat.—Formosa.

Holotype, male, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

All of the Formosan species of *Ormosia* known to me have this apparent duplication of the ninth tergite, there being a paler and thicker flattened structure immediately beneath the outer tergal plate.

ILLUSTRATIONS

[Legend; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapophysis; *i*, interbasal process; *id*, inner dististyle; *od*, outer dististyle; *t*, ninth tergite; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Nesopeza basistylata* sp. nov., venation.
2. *Stibadocerella formosensis* sp. nov., venation.
3. *Stibadocerella pristina* Brunetti, venation.
4. *Cyttaromyia taiwania* sp. nov., venation.
5. *Limonia (Libnotes) clitelligera* sp. nov., venation.
6. *Limonia (Limonia) tenuicula* sp. nov., venation.
7. *Limonia (Dicranomyia) aurita* sp. nov., venation.
8. *Limonia (Dicranomyia) montium* sp. nov., venation.
9. *Limonia (Alexandriaria) atayal* sp. nov., venation.
10. *Orimarga fuscivenosa* sp. nov., venation.
11. *Thaumastoptera (Taiwanita) issikiana* sp. nov., venation.
12. *Helius (Helius) liliputanus* sp. nov., venation.
13. *Ula fuscistigma* sp. nov., venation.
14. *Pseudolimnophila autumnalis* sp. nov., venation.
15. *Troglophila ritozanensis* sp. nov., venation.
16. *Limnophila rantaizana* sp. nov., venation
17. *Pilaria formosicola* sp. nov., venation.
18. *Neolimnophila alticola* sp. nov., venation.
19. *Lipsothrix pluto* sp. nov., venation.
20. *Gnophomyia dejecta* sp. nov., venation.
21. *Gnophomyia brevicellula* Alexander, venation.
22. *Trentepohlia (Mongoma) atayal* sp. nov., venation.
23. *Trentepohlia (Mongoma) tarsalba* sp. nov., venation.
24. *Ormosia shōreana* sp. nov., venation.

PLATE 2

FIG. 25. *Nesopeza basistylata* sp. nov., male hypopygium.
26. *Limonia (Limonia) tenuicula* sp. nov., male hypopygium.
27. *Limonia (Dicranomyia) aurita* sp. nov., male hypopygium.
28. *Limonia (Dicranomyia) montium* sp. nov., male hypopygium.
29. *Thaumastoptera (Taiwanita) issikiana* sp. nov., male hypopygium.
30. *Helius (Helius) nawaianus* sp. nov., male hypopygium, dististyle.
31. *Helius (Helius) nipponensis* Alexander, male hypopygium, dististyle.
32. *Helius (Helius) liliputanus* sp. nov., male hypopygium.
33. *Pseudolimnophila autumnalis* sp. nov., male hypopygium.
34. *Limnophila rantaizana* sp. nov., male hypopygium.
35. *Neolimnophila alticola* sp. nov., male hypopygium.
36. *Gnophomyia dejecta* sp. nov., male hypopygium.
37. *Gnophomyia brevicellula* Alexander, male hypopygium.
38. *Ormosia shōreana* sp. nov., male hypopygium.

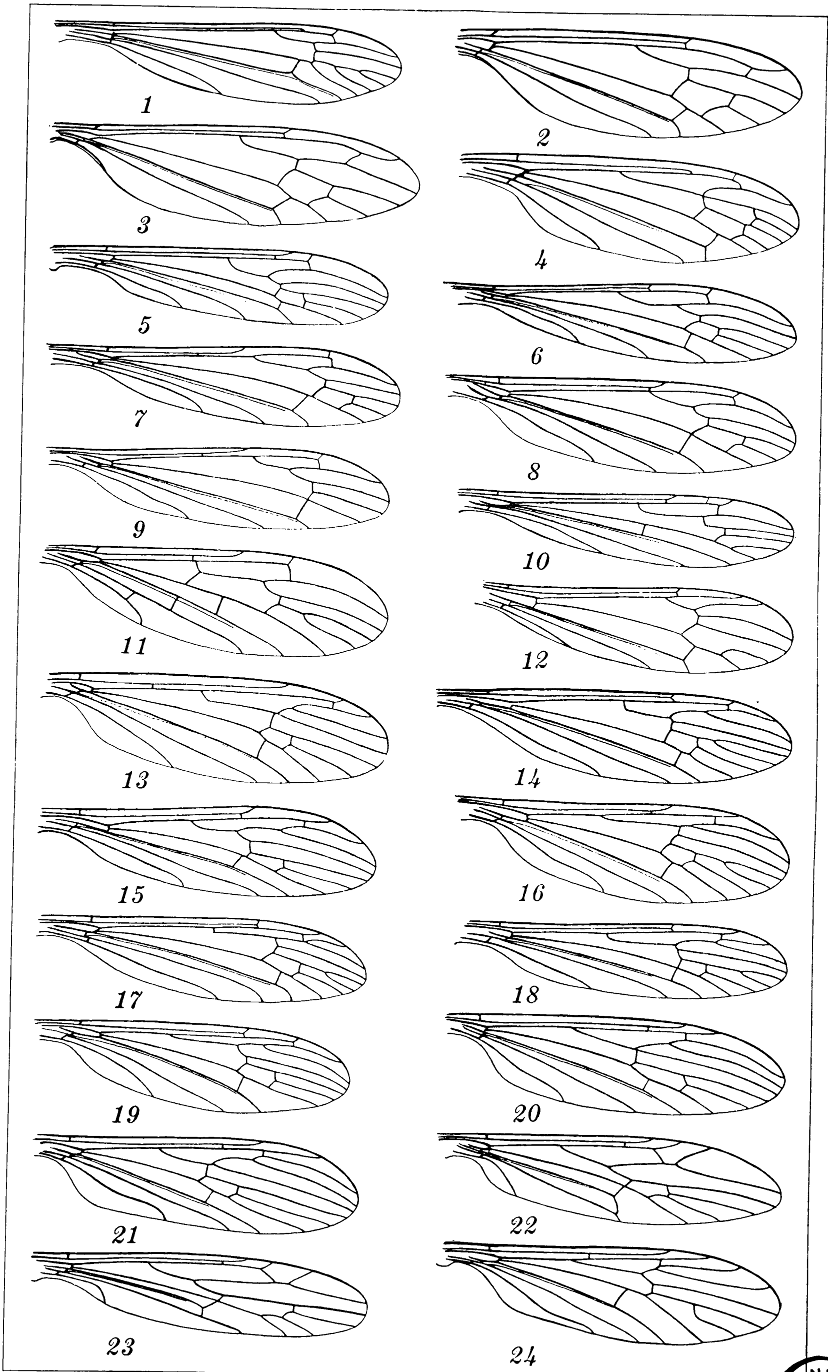

PLATE 1.

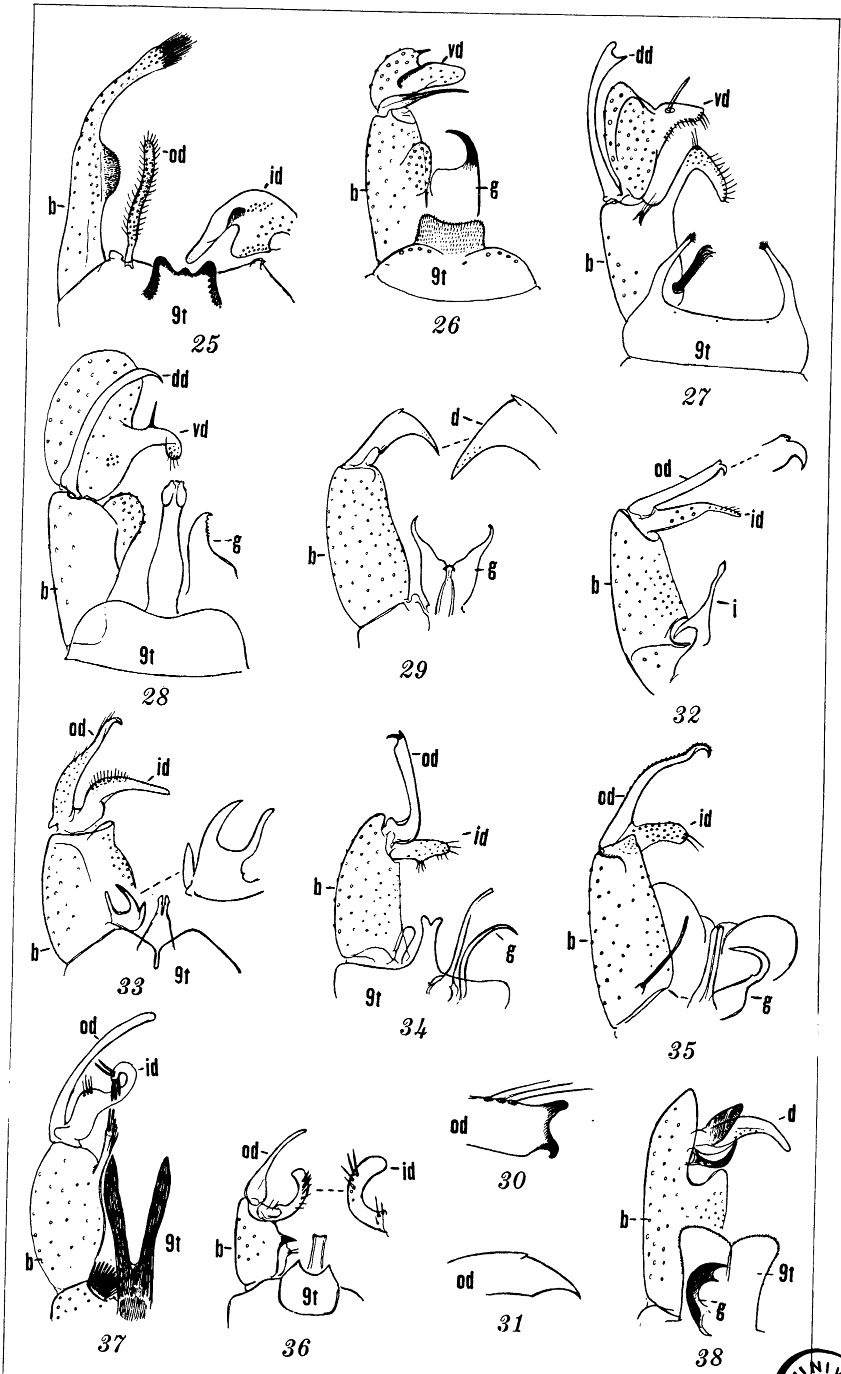

PLATE 2.

ERRATA

The following tables are to be substituted for the corresponding tables on pages 77, 86, 84, 85, and 87, respectively.

TABLE 1.—*Showing the serologic results after subcutaneous, intraperitoneal, and intramuscular vaccination against yaws.*

[+, 25 per cent inhibition of hæmolysis; ±, less than 25 per cent inhibition of hæmolysis; —, complete hæmolysis; 0, not done.]

Designation of monkey.	Date and modus of vaccination.			Wassermann reaction. Results and dates.				Revaccination, VIII-4-28.	Wassermann reaction after revaccination.	
	First, VI-14-28.	Second, VI-22-28.	Third, VI-30-28.	Before vaccination, VI-13-28.	After vaccination.				VIII-16-28.	VIII-30-28.
					VII-13-28.	VII-27-28.	VIII-2-28.			
c-1	Intrap	Intrap	Intrap	—	—	—	—	Intrap	—	—
c-2	do	do	do	—	—	—	—	do	—	—
d-1	Intram	Intram	Intram	—	—	—	—	Intram	—	—
d-2	do	do	do	—	—	—	—	do	—	—
d-3	0	Subcut	Subcut	—	—	±	+	Subcut	±	+
d-4	0	do	do	—	—	±	—	do	±	—

TABLE 2.—*Showing the serologic results after subcutaneous, intraperitoneal, and intramuscular vaccination against yaws. Both Wassermann and Kahn reactions considered.*

Designation of monkey.	Date and modus of vaccination.			Wassermann reaction. Results and dates.				Revaccination, VIII-4-28.	Wassermann and Kahn reaction after revaccination.	
	First, VI-14-28.	Second, VI-22-28.	Third, VI-30-28.	Before vaccination, VI-13-28.	After vaccination. VII-13-28.	VII-27-28.	VIII-2-28.		VIII-16-28.	VIII-30-28.
c-1	Intrap.	Intrap.	Intrap.	—	—	—	—	Intrap.	—	—
				—	—	—	—		—	—
c-2	do.	do.	do.	—	—	—	—	do.	—	—
				—	—	—	—		—	—
d-1	Intram.	Intram.	Intram.	—	—	—	—	Intram.	—	—
				—	—	—	—		—	—
d-2	do.	do.	do.	—	—	—	—	do.	—	—
				—	—	—	—		—	—
d-3	0	Subcut.	Subcut.	—	—	±	+	Subcut.	±	+
				±	++	++	++++		++++	+++
d-4	0	do.	do.	—	—	±	—	do.	±	—
				±?	—	—	—		—	—

The marks above are for Wassermann reaction. The marks below are for Kahn test.

Table 1.—*Showing the results of Wassermann and Kahn tests performed on yaws-vaccinated monkeys.*

[—, complete hæmolysis; ±, less than 25 per cent inhibition; +, 25 per cent inhibition; ++, 50 per cent inhibition; +++, 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done; l, lens. For interpretation of Kahn test see text.]

Designation of monkey.	Vaccination.						Vaccine killed 1 hour at—	After vaccination.			
	Number.	Date.	Number.	Date.	Number.	Date.		Wassermann reaction before vaccination.	Date.	Result of— Wassermann reaction.	Result of— Kahn test.
W-57	1	III- 5-28	2	III-12-28	3	III-20-28	80° C.	—	IV- 7-28	+++	0
									V- 3-28	++	+ l
									V-28-28	—	—
W-58	1	III- 5-28	2	III-12-28	3	III-20-28	80° C.	—	IV- 7-28	+++	0
									V- 3-28	+	± l
									V-28-28	—	—
W-59	1	III- 5-28	2	III-12-28	0		80° C.	—	IV- 7-28	++	0
									V- 3-28	+	+ l
									V-28-28	±	—
									VI-21-28	±	—
									VII- 6-28	—	—
									VII-18-28	—	—
W-60	1	III- 5-28	0	III-12-28	0		80° C.	=	IV- 7-28	+	0
									V- 3-28	±	± l
									V-28-28	±	—
W-61	1	III- 5-28	0		0		80° C.	—	IV- 4-28	—	0
									V- 3-28	+	—
									V-28-28	+	—
									VII- 6-28	—	—
									VII-18-28	—	—
									VII-30-28	—	—

W-63	1	III- 5-28	2	III-14-28	3	III-20-28	[a] 80° C.	—	IV- 7-28	—	0
									V- 3-28	±	± [1]
									V-28-28	—	—
									VII-18-28	—	—
									IX-18-28	—	—
W-64	1	III- 5-28	2	III-14-28	3	III-20-28	[a] 80° C.	=	IV- 7-28	±	0
									V- 3-28	+	—
									V-28-28	—	—
									VII-18-28	—	—
									IX-18-28	—	—
K-9	1	IV-11-28	1	IV-16-28	1	IV-27-28	100° C.	—	V-17-28	+	±
A-8	1	IV-11-28	1	IV-16-28	1	IV-27-28	100° C.	—	V-17-28	+	± [1]
J-18	1	IV-16-28	1	IV-27-28	0	----------	100° C.	—	V-17-28	++++	+++

[a] Diluted.

TABLE 3.—*Showing the result of Wassermann reaction and of Kahn test in monkeys immunized with normal and inflammatory tissues from normal skin of normal and yaws monkeys.*

[—, complete hæmolysis; ±, less than 25 per cent inhibition; +, 25 per cent inhibition; ++, 50 per cent inhibition; +++, 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done. For interpretation of Kahn test see text.]

Designation of monkey.	Material used for subcutaneous vaccination.	Date and result of Wassermann and Kahn reactions after immunization.		Date and result of inoculation with yaws.	Date and result of Wassermann and Kahn reactions after infection and superinfection with yaws treponemas.							
R-3	Normal skin from normal monkey.	VI-20-28 [a] — ± 1	VII-5-28 — —	VII-19-28 yaw	IX-3-28 — ±	IX-13-28 — +	IX-27-28 — ++	X-10-28 Dead	X-23-28 Dead	X-31-28 Dead	0	
R-4	do	VI-20-28 — —	VII-5-28 — —	VII-19-28 yaw	IX-3-28 — ± 1	IX-13-28 — ±	IX-27-28 — +	X-10-28 — —	X-23-28 + +	X-31-28 — +	0	
S-4	Normal skin tissue from yaws monkey.	VI-20-28 — —	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-23-28 ± +	X-31-28 — —	0	
A-1	Inflammatory skin tissues from normal monkey.	VII-2-28 — —	VII-16-28 — —	VII-31-28 yaw	IX-3-28 — —	IX-13-28 ++ —	IX-27-28 — —	X-10-28 — —	X-23-28 + —	X-31-28 ± —	0	
A-2	do	VII-2-28 — +	VII-16-28 — ++	VII-31-28 yaw	IX-3-28 — ++++	IX-13-28 +++ ++++	IX-27-28 + ++++	X-10-28 +++ ++++	X-23-28 ++ +	X-31-28 ± +	0	
Z-1	Inflammatory skin tissues from yaws monkey.	VI-20 28 — —	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-10-28 — —	X-31-28 — —	XI-14-28 ± —	XI-7-28 — +
Z-2	do	VI-20-28 — ± 1 ?	VII-5-28 — —	VIII-2-28 yaw	IX-3-28 — —	IX-13-28 — —	IX-27-28 — —	X-10-28 — —	X-10-28 — —	X-31-28 — —	XI-14-28 ± —	XII-7-28 — —

[a] The marks above are for Wassermann reaction. The marks below are for Kahn test.

INDEX

[New names and new combinations are printed in **boldface**.]

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The Philippine Journal of Science is issued twelve times a year. The sections were discontinued with the completion of Volume XIII (1918).

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